THE INSTITUTE OF PHYSICS

BULLETIN

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THE INSTITUTE OF PHYSICS

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Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

University of Glasgow
UNIVERSITY STUDENTSHIPS AND FELLOWSHIPS

Applications are invited for University Studentships and Fellowships for experimental or theoretical research in solid state physics. Salary scale : Studentships, £350 – £600 per annum, according to qualifications with a tenure of three years. Fellowships, £700 – £900 per annum, according to qualifications. Tenure three years on appointment, with possible renewal for further period of two years. These Fellowships will be superannuated under the F.S.S.U. Applications stating age, academic qualifications, research experience and names of two referees, should be sent to the Professor of Natural Philosophy, University of Glasgow, before May 7, 1960.

THE COLLEGE OF AERONAUTICS

Applications are invited for a RESEARCH FELLOWSHIP in Polymer Science in the Department of Materials. Candidates must be university graduates with a good research background, and should preferably have a higher degree, or be intending to work for one. Publication is encouraged and the choice of research is wide. Salary in the ranges : Senior Research Fellow, £1,100 to £1,350 ; Research Fellow, £750 to £1,000 per annum, with superannuation under F.S.S.U. and family allowance. Appointment will be made initially for three years with prospects of continuation.

Applications containing full particulars and quoting the names of three referees, should be addressed to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG
Chair of Mathematics

Applications are invited for appointment to the post of Professor of Mathematics and Head of the Department of Mathematics. Duties are to be assumed as soon as possible in 1960. The salary attached to the appointment will be according to scale £2,500 × 100 – £2,800. The initial notch will be determined in accordance with the qualifications and experience of the successful candidate. In addition the University is at present authorized to pay an annual vacation savings bonus of £60 to a married man. Membership of the University Institutions Provident Fund and the University's Staff Medical Aid Fund is compulsory. Intending applicants may obtain a copy of the information sheet relating to this vacancy from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in South Africa and London, on May 31, 1960.

SUNDERLAND EDUCATION AUTHORITY
SUNDERLAND TECHNICAL COLLEGE

Applications are invited for the post of LECTURER in the Physics Department. Candidates must be well qualified and preference will be given to those who have had teaching and industrial experience. Salary : Burnham scale for Lecturers, £1,370 by increments of £35 to £1,550 per annum. Particulars from the Registrar, Technical College, Sunderland, Co. Durham. Applications should reach the undersigned as soon as possible. Canvassing disqualifies.

W. Thompson, Director of Education, Education Offices, 15 John Street, Sunderland, Co. Durham.

Essex
SOUTH-EAST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART
Longbridge Road, Durham

Required September, 1960 : LECTURER IN PHYSICS. Applicants should have a good honours degree in physics, with teaching and/or research experience. Further details and application forms (foolscap S.A.E.) from the Clerk to the Governors.

INSTITUTE OF CANCER RESEARCH : Royal Cancer Hospital. Applications are invited by the Department of Physics from honours graduates in physics, chemistry or in a biological subject, for Studentships leading to the degrees of Ph.D. or M.Sc. in biophysics (University of London). The aim of these Studentships is to provide facilities for basic training in the branches of physical and biological science appropriate to the peaceful uses of atomic energy. The Studentships normally extend over two or three years and carry an allowance of £400 per annum. Detailed applications, naming two referees, for places available from October 3, 1960, should be received by the Secretary, 33 Sumner Place, London, S.W.7, not later than April 20, 1960.

UNIVERSITY OF ABERDEEN
Natural Philosophy Department

Applications invited for LECTURESHIPS and ASSISTANTSHIPS (teaching posts) in experimental physics, theoretical physics and electronics. Salaries : Lecturers, £900 × £50 – £1,350 (Bar) × £75 – £1,650 ; Assistants, £700 × £50 – £850, with F.S.S.U., child allowance, and part removal expenses. Initial placings according to qualifications and experience. Particulars and forms of application from the Secretary, The University, Aberdeen, with whom applications (eight copies) should be lodged by May 10, 1960. Applicants outside the British Isles may submit one copy of application.

LIVERPOOL RADIUM INSTITUTE MANAGEMENT COMMITTEE
1 Myrtle Street, Liverpool, 7

Applications are invited for the post of BASIC GRADE PHYSICIST in the Radioisotope Department of the Liverpool Radium Institute. Salary within the range £570 – £1,035, according to qualifications and previous experience. This department provides a radioisotope service for the Liverpool Region and a number of diagnostic and therapeutic radioisotope techniques are currently being used. The successful applicant will be required to take a full share in the work of the department and in the development of new equipment and applications. Applications, giving full details of education and previous experience, should be addressed to the Secretary within seven days of the date of this advertisement.

UNIVERSITY COLLEGE OF WALES, ABERYSTWYTH

Applications are invited for the following posts to commence duties on October 1, 1960 : (*a*) LECTURER IN PHYSICS with special emphasis on electronics. (*b*) LECTURER IN PHYSICS. Further particulars can be obtained from the Registrar, to whom applications should be sent not later than April 25, 1960.

RESEARCH ASSISTANT

required in a small department working on background and applied research on engineering and chemical engineering problems, involving lively contact with engineering and works departments, including theoretical and laboratory investigations, testing on site, and pilot plant design, operation and testing followed by full-scale plant design ; with a degree in mechanical or chemical engineering, physics, or chemistry and a sound imaginative approach to problems, which is more important than previous experience. Send detailed written applications immediately, mentioning this advertisement and quoting 15/60, to The Staff Officer, Whessoe Ltd., Darlington.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
St. John Street, London, E.C.1

Applied Physics Department. TWO READERS in physics. The holders of these Readerships will be required to devote the majority of their time to the development of research in their specialized fields and the supervision of research students. Since the Department is primarily concerned with the Diploma in technology, and postgraduate courses, all of which involve close collaboration with industry, it is desirable that applicants should be specialized in some branch of applied physics. Salary Scale: £1,800 × £50–£2,100 per annum, plus London Allowance of £38, increasing to £51 at age 37. Particulars and forms of application from the Secretary.

BIRKBECK COLLEGE

(University of London)

Session 1960/61

begins

Monday, October 3, 1960

Part-time (evening) courses provided for Internal degrees in the Faculties of Arts and Science. Facilities also provided for full-time and part-time students reading for

(i) Higher degrees by thesis in Arts and Science,

(ii) M.A. and M.Sc. Mathematics and M.Sc. Crystallography by examination.

(iii) Academic postgraduate Diplomas in Psychology and Numerical Analysis.

The College also invites applications from full-time and part-time students wishing to take by thesis high degrees in Statistics.

The Department of Scientific and Industrial Research has accepted the Postgraduate Diplomas courses in Psychology and Numerical Analysis and the M.Sc. Crystallography course, as suitable for tenure of its Advanced Course Studentships. Students intending to read for Higher Degrees in Science by thesis are invited to enquire of the College whether it has available any D.S.I.R. Research Studentships.

Applications for admission to the College should be made before June 1.

Pamphlet and form of application may be obtained from the

Registrar
BIRKBECK COLLEGE
MALET STREET, W.C.1

UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF ENGINEERING
POSTGRADUATE COURSE IN CONTROL ENGINEERING

The 1960-61 postgraduate course in control engineering will begin on October 5, 1960, and will last approximately nine months. This course has been established in order to meet the needs of industry for men trained to a high standard in the theoretical principles and practical application of automatic control and to afford opportunity for study of advanced techniques and modern development in the general field of control engineering. The number of students will be limited and applications must reach the Secretary of the Department not later than May 31, 1960. Candidates should hold a degree in engineering or a suitable alternative qualification and have had some practical training and experience. They may be required to attend for interview in Cambridge. Further details and forms of application for admission may be obtained from the Secretary, Cambridge University, Department of Engineering, Trumpington Street, Cambridge.

THE SCIENTIFIC CIVIL SERVICE needs men and women for pensionable posts as (*a*) SENIOR SCIENTIFIC OFFICERS and (*b*) SCIENTIFIC OFFICERS in all major scientific fields, including physics, chemistry, biology, meteorology and mathematics. Some particular vacancies include :—PHYSICISTS / ELECTRICAL ENGINEERS for research in the application of servo-control for machine tools. PHYSICAL CHEMISTS, CHEMISTS for research in high polymers, BOTANIST for study of bryophyta, PHYSIOLOGIST for work at the Institute of Aviation Medicine, PALAEONTOLOGISTS to specialize in paleobotany and for work on fossil mollusca, MINERALOGIST to work on meteorites (Petrologist with sound knowledge of physics preferred). ZOOLOGISTS to specialize in the taxonomy of the porifera and in serological and other histo-chemical techniques applicable in zoology and anthropology. Qualifications : normally first or second class honours degree in science, mathematics or engineering, or equivalent attainment ; additionally, for (*a*), at least three years' relevant (e.g post-graduate) experience. Normal age limits: (*a*) between 26 and 32, (*b*) between 21 and 29, with extension for regular Forces Service and Overseas Civil Service. London salaries (men) : (*a*) £1,233 – £1,460, (*b*) £655 – £1,150 ; provision for starting pay above minimum. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting (*a*) S/53/60, (*b*) S/52/60.

A senior and experienced MICROWAVE PHYSICIST is required by Laboratories RCA Ltd., to establish and direct a research program in its Zürich laboratories presently engaged in other solid state research. Austin Knight Advertising Ltd., Box AS.3037, 212a Shaftesbury Avenue, London, W.C.2.

D.S.I.R. requires SCIENTIFIC OFFICER / SENIOR SCIENTIFIC OFFICER for project appraisal/design study at Warren Spring Laboratory, Stevenage, Herts, as member of team carrying out economic assessment of new projects based on operational research and statistical studies. Candidates should have strong interest in economics and be familiar with statistical techniques but not necessarily economists or statisticians. Flair for formulating or programming design problems of chemical engineering nature desirable with an appreciation of basic technical processes involved. Laboratory's present interests are centred mainly around inorganic applied chemistry and include chemical engineering, process development, mineral processing and extractive metallurgy. Qualifications : 1st or 2nd class honours degree in chemistry, chemical engineering, economics, physics or metallurgy or equivalent. Minimum three years' post-graduate experience for Senior Scientific Officer. Salary : (men, Scientific Officer £615 – £1,090 ; Senior Scientific Officer £1,166 – £1,380.) Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting reference F 782/9A. Closing date May 23, 1960.

ROYAL TECHNICAL COLLEGE, SALFORD
DEPARTMENT OF PURE AND APPLIED PHYSICS

Applications are invited from suitable candidates for the HEADSHIP of this Grade V Department. Salary scale : £2,100 rising to £2,250 per annum. The Department is recognized for the award of the Diploma in Technology in applied physics, and has an active research school. Interesting and extensive developments are taking place both in the College and in the Department. High academic qualifications essential; industrial and/or research experience desirable; teaching experience desirable but not essential. Further particulars and forms of application can be obtained from the Registrar, Royal Technical College, Salford 5, Lancs., to whom completed applications should be returned by April 20, 1960. R. Ribblesdale Thornton, Clerk to the Governors.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
ST. JOHN STREET, LONDON, E.C.1
APPOINTMENT OF HEAD OF DEPARTMENT OF OPHTHALMIC OPTICS

The Governing Body invites applications for the Headship of the Ophthalmic Optics Department, which provides full-time and part-time courses for the education and training of ophthalmic opticians and is concerned with an expanding field of postgraduate courses and research. Applicants should have qualifications in ophthalmic optics or physics. The salary scale is £1,950 rising by annual increments of £50 to £2,100 per annum, plus a London Allowance of £38 increasing to £51 at the age of 37. The post is pensionable. Further particulars and forms of application obtainable from the Secretary of the College.

TUBE INVESTMENTS

RESEARCH AND DEVELOPMENT DIVISION

Tube Investments invite applications for appointment to the scientific and engineering staff of their Technological Centre in Aldridge, Staffordshire. Applicants should be in the age range 24 to 35 years and possess an Honours Degree or its equivalent. Previous industrial experience is desirable but not essential.

Staff are required for process research and engineering development in the following fields :—

1. METALLURGY with particular reference to beryllium and other "nuclear" metals including cermets.
2. ELECTRONICS with particular reference to new techniques of inspection based on eddy current and ultrasonic measurement.
3. ELECTRICAL ENGINEERING with particular reference to automatic control mechanicsm using transistor and other electronic circuits.
4. WELDING with particular reference to development of new techniques for welding.

The salary offered will be in accordance with age and experience and applications should be addressed to

The Director, T.I. Technological Centre, The Airport, Walsall, Staffordshire

PHYSICIST

A physicist is required for work on the design of educational physics apparatus. Teaching experience, preferably in a Technical College, and a mechanical mind would be an advantage. The place of work will be in or near Wembley, Middlesex.

Applications should be made to the

DIRECTOR OF RESEARCH
GRIFFIN AND GEORGE
(R & D) LTD.
"ABBOTSBURY"
BARNET LANE, ELSTREE

SCIENTISTS AND TECHNOLOGISTS

B.I.P. Chemicals Ltd. have vacancies for **Scientists** and **Technologists** in their laboratories at Oldbury. The appointments will be in the Research Development, or Analytical and Testing Departments, which are undergoing considerable expansion, and opportunities will arise later for transfer to other Departments, or to other Companies within the British Industrial Plastics Ltd. Group. The desirable minimum qualification is a good honours degree, A.R.I.C. or A.P.I., and the preferred age range is 21-35. Post-graduate or industrial experience will be an advantage for some of the appointments.

Specialized experience in such fields as analytical, organic or physical chemistry, rheology, statistical methods, applied physics, chemical engineering, synthetic resins, or plastics and resins technology, would be particularly relevant.

The Company offers good conditions of employment, including a Pension and Life Assurance Scheme, and encourages participation in the activities of scientific and technical societies. *Please write giving details of qualifications and experience to :*

Personnel Manager,
B.I.P. Chemicals Ltd., Oldbury,
Birmingham

PULP AND PAPER RESEARCH INSTITUTE OF CANADA

requires

ELECTRON MICROSCOPIST

To supervise operation and maintenance of the Institute's new scanning electron microscope developed recently at Cambridge University. Requirements : preferably a university graduate with special training and experience in electron microscopy.

Work will be in the Institute's Pointe Claire Laboratories in a residential suburb of Montreal.

Applications, with full résumé of education and experience, should be made in writing to :—

Chief Personnel Officer
Pulp and Paper
Research Institute of Canada
3420 University Street
Montreal, Quebec
Canada

ASSOCIATED LEAD MANUFACTURERS LTD.

The Cookson House Research Laboratories of Associated Lead Manufacturers Ltd. (part of the Goodlass Wall and Lead Industries Ltd. Group) require the following senior research workers :— 1. A CHEMIST OR METALLURGIST to work on the extraction and refining of antimony and the production of antimony oxide. The successful applicant will (*a*) be a physical or inorganic chemist or a metallurgist with a good honours degree and probably a research degree ; (*b*) have had several years' industrial research experience, probably in the field of non-ferrous metallurgy ; (*c*) be aged 30-40. 2. A CLASSICAL PHYSICIST to work on a variety of problems including glass polishing, production of dielectric materials and the classification of fine powders. The successful applicant will (*a*) have a good honours degree and probably a research degree; (*b*) have had several years' research experience including; some industrial experience; (*c*) be aged about 30-35. Both the above positions are permanent and offer scope for advancement. The research laboratories are in Wallsend, within easy reach of the Northumbrian coast and Newcastle upon Tyne. Working conditions are good and salaries will be related to qualifications and experience. Apply to Research Manager, Associated Lead Manufacturers Ltd., Cookson's Antimony Works, Willington Quay, Wallsend, Northumberland.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY

St. John Street, London, E.C.1

Applied Physics Department. Applications are invited for the following new appointments made necessary by the expansion of the work of the Department, which is primarily concerned with the Diploma in technology and postgraduate courses. (*a*) SENIOR LECTURER, (*b*) LECTURER, (*c*) ASSISTANT LECTURER. Preference will be given to applicants with special interest in one or other of the following fields: (1) Nuclear Technology; (2) Automatic Control and Electronics. Successful applicants will be encouraged to undertake research or development work and may be required to assist in industrial liaison. Salary scales. Senior Lecturer: £1,550 × £50–£1,750 per annum. Lecturer: £1,370 × £35–£1,550 per annum. Assistant Lecturer: £895 × £27 10s.–£1,345 per annum. Plus, in each case, a London Allowance of £38, increasing to £51 at age 37. Starting salary dependent upon industrial or teaching experience. Particulars and form of application from the Secretary. Successful applicants will be required to take up the appointment not later than September 1, 1960.

UNIVERSITY COLLEGE OF THE WEST INDIES

Applications are invited for (*a*) SENIOR LECTURESHIP or (*b*) LECTURESHIP in (i) experimental physics *and* (ii) theoretical physics. Salary scales (under review) :—(*a*) £1,500 × 75 – £2,250 p.a., (*b*) £1,150 × 50 – 1,450 × 75 – £1,900 p.a. Entry point determined by qualifications and experience. Child allowance. F.S.S.U. Unfurnished accommodation at rent 5% basic salary. Passages for up to five persons on appointment, normal termination and study leave (once every three years). Detailed applications (six copies) naming three referees by May 10, 1960, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF GLASGOW
UNIVERSITY STUDENTSHIPS AND FELLOWSHIPS

Applications are invited for University Studentships and Fellowships for experimental or theoretical research in nuclear and elementary particle physics. Salary scale :—Studentships : £350 – £600 per annum, according to qualifications with a tenure of three years. Fellowships : £700 – £900 per annum, according to qualifications. Tenure three years on appointment, with possible renewal for further period of two years. These Fellowships will be superannuated under the F.S.S.U. Applications stating age, academic qualifications, research experience and names of two referees, should be sent to the Professor of Natural Philosophy, University of Glasgow, before April 30, 1960.

Plessey

LEIGH ELECTRONIC DEVELOPMENTS LIMITED

NEW LANE, HAVANT, HANTS

This subsidiary of The Plessey Company Limited is engaged on a forward-looking programme of research and development on new and revolutionary vacuum devices and their applications. The following posts offer excellent opportunities for advancement in an expanding organization.

GROUP LEADER

A Physicist or Engineer, well qualified and having several years in the design and analysis of circuitry using valves and transistors. The work will involve the development of equipment for use in extreme environments and miniaturisation techniques.

PHYSICIST OR ELECTRONICS ENGINEER

(*a*) Well qualified, with an interest in electronic component applications. A number of posts are available and new graduates will be considered.

(*b*) For work involving the statistical and quality control of electronic valves. H.N.C. or Pass Degree standard. Experience in valve testing or electronics an advantage.

ELECTRONIC ENGINEER

To design and develop factory test equipment under supervision. Minimum qualification O.N.C.

The above appointments carry pension and life assurance benefits. Assistance with rented housing can be given in certain circumstances.

Applications, which will be treated in confidence, should be sent to the

REGIONAL PERSONNEL MANAGER, THE PLESSEY COMPANY LIMITED, NEW LANE, HAVANT, HANTS.

Please quote reference LED/4.

THE INSTITUTE OF PHYSICS
Vol. 11 No. 4 BULLETIN APRIL, 1960

Published by The Institute of Physics for circulation to its members

New Uses for Low Temperatures

Professor G. O. JONES
M.A., B.Sc., Ph.D.
Queen Mary College, University of London

[Based on a lecture to the London and Home Counties Branch of the Institute on October 29, 1959.]

INTRODUCTION

The real importance of low temperature is that it is one of the main tools in the study of the fine structure of matter, as we see very simply by writing the cryptic formulae:

$$kT = \varepsilon = \frac{hc}{\lambda},$$

which relate the quantum energy jump (ε) of a radiative transition to the wavelength (λ) of radiation emitted or absorbed and to its characteristic temperature (T). Putting in corresponding figures we may write, for example:

$$1°K \equiv 10^{-4} eV \equiv 1 \text{ cm}.$$

Then we see that at the lowest temperatures we shall be studying processes connected with the smallest energy gaps, or the weakest forces, and these will also be the processes studied in spectroscopy at the longest wavelengths. For example, the techniques of low temperature physics and of microwave spectroscopy become complementary in the study of the influence of nuclear spin on the electronic magnetic field, which is responsible for one kind of hyperfine structure in optical spectra. Superconductivity, a phenomenon which occurs only at very low temperatures, is due to a very weak attractive force between electrons and again may be studied by spectroscopy in the far infra-red and microwave region.

At intermediate temperatures we shall be studying intermediate energy gaps, such as those between different states of orientation of non-spherical molecules in molecular crystals, which give rise to the very many so-called " λ-points " in specific heat curves, spread out over the whole range of temperature below room temperature, or forces of intermediate strength, such as those between atoms of the solidified rare gases.

It is useful to know at what temperatures the main phenomena of low temperature physics occur and in Figure 1 is shown a chart showing where these tempertures stand in relation to the main fixed points—the boiling points of the liquids used as coolants. The fact that it is necessary to use an exponential scale in the preparation of this diagram is some indication of the way in which low temperature physics becomes more and more interesting at lower and lower temperatures. An idea of its increasing importance is suggested by the fact that at least 80,000 litres of liquid helium are consumed in the United States each year. At the Massachusetts Institute of Technology, for example, a greater volume of liquid helium was used in 1957 than that of liquid air used in 1947.

However, low temperature can provide rewards quite different from those already mentioned, as indicated in the right-hand panel of the diagram. Used as a technique it can often add greatly to the power of other techniques in experimental physics. Also, some of the phenomena of the liquid helium range ($\approx 4°K$)—especially those associated with superconductivity—may be used as the basis for instruments and devices entirely novel in character. In the present article we discuss this new aspect of the use of low temperature. It has already reached the point at which it is safe to say that if liquid helium is not now being sent up in rockets, this will be done in a year or two.

PREDICTABLE USES OF LOW TEMPERATURE

We begin by discussing some of the new uses of low temperature of the kind which could have been predicted by considering the nature of low temperature. The first effect of reducing temperature is of course to reduce molecular motions of all kinds, and this can be used to reduce the Doppler width and increase the resolution in spectroscopy. For example, the Balmer series in deuterium has been studied by running a deuterium discharge in a tube immersed in liquid hydrogen ($\approx 20°K$). Similarly, the overlapping of absorption bands may be reduced by working at low temperature, and the absorption of naphthalene has been studied at about $30°K$ for this reason.

More recently the reduction of thermal noise at low temperature has become of prime importance in the development of sensitive detectors of radiation, especially for the infra-red and far infra-red regions. It is be-

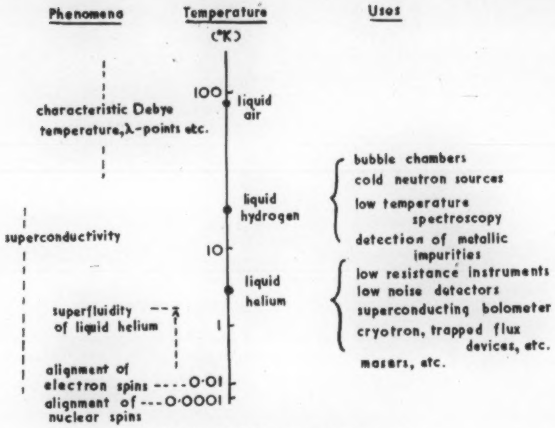

Phenomena
Temperature (°K)
Uses
100
10
1
characteristic Debye temperature, λ-points etc.
superconductivity
superfluidity of liquid helium
alignment of electron spins
0·01
alignment of nuclear spins
0·0001
liquid air
liquid hydrogen
liquid helium
bubble chambers
cold neutron sources
low temperature spectroscopy
detection of metallic impurities
low resistance instruments
low noise detectors
superconducting bolometer
cryotron, trapped flux devices, etc.
masers, etc.

Fig. 1. *Chart of low temperature phenomena.*

coming very frequent practice to cool such detectors to the boiling-point of liquid helium even if their action does not itself depend upon a low-temperature property (as it does in the case of the superconducting bolometer—to be discussed later). Some of the newer photoconductive detectors, such as those based on " doped " germanium, have long-wave " cut-offs " beyond 120μ Here the thermal noise, reduced by cooling, arises from fluctuations in the total number of carriers due to variations in the rates of generation and recombination.

Low temperature enters into microwave spectroscopy in another way. Here, where many of the transitions under study are " forbidden," it is necessary to work at low temperature in order to increase the absorption. (If $h\nu \ll kT$ the number of transitions is roughly proportional to $\frac{h\nu}{kT}$).

In neutron spectroscopy low temperature enters in a fundamental way, since it provides the most direct method for obtaining beams of neutrons of very long wavelength. A few years ago it was reported from Harwell that the flux of " very cold " neutrons—in the range 5 to 10A—could be increased by a factor 25 by the use of liquid hydrogen as moderator. It was calculated that a moderator of the same size at liquid helium temperature would increase the flux of neutrons of very long wavelength by 10^4.

OTHER USES OF LOW TEMPERATURE

The well-known " bubble chamber " used in nuclear physics may be regarded as an accidental use of low temperature. The main requirement in bubble chambers is that the liquid should have low atomic number, in order to reduce Coulomb scattering. So pentane, sulphur dioxide and many other substances are used. The special advantage of hydrogen is that it presents a pure proton target and this is mainly why liquid hydrogen in bulk is becoming an important material in nuclear physics.

Has liquid *helium* any uses in its own right except as a coolant ? There is at least one attempt being made to use the " superfluid " properties of liquid helium which appear below 2·19°*K*. Because the viscosity at 0°*K* vanishes identically it is possible in principle to study pure fluid hydrodynamics, and experiments have been performed on the " lift " of a small aerofoil in liquid helium. Of course, it is not possible to work at absolute zero, but the same result is obtained if only the superfluid component of the liquid is moving relative to the aerofoil. In these experiments it was possible by making use of the " fountain effect " to keep the normal component of the fluid stationary and to cause a controlled velocity in the superfluid component.

The progressive lowering of electrical resistance at low temperature is often made use of. As shown in Figure 2, the electrical resistance of all metals falls away at low temperature, the slope of the curve of resistance *vs.* temperature tending towards zero. There is still, however, a *residual resistance*, due to physical or chemical impurities—except in a superconducting metal, where it vanishes sharply at a temperature characteristic of the particular metal.

There is first a group of applications which simply make use of the lowering of resistance. For example, it is possible to make solenoids much smaller if they can be run at low temperature, because of the reduced Joule

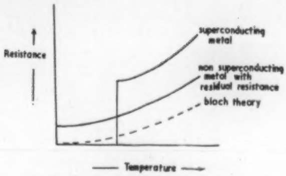


Fig. 2. *Electrical behaviour of metals.*

heating. It is also possible to make transformers of very high turns-ratio—for matching low-impedance sources to high impedance amplifiers, for instance—by using very fine wires and running the transformer at low temperature. Similarly, coils may be made to operate with high quality factor, *Q*. For example, a coil used at 1,000 c/s, having *Q* of 1·75 at room temperature, had *Q* of 88 at liquid helium temperature. (If the wire is superconducting even higher values can be employed —at least up to 10^7!)

The magnitude of the residual resistance, being a measure of the impurity of the metal, can be used to judge the effectiveness of a purification process. If a number of potential leads are arranged at intervals along a bar which is to be purified by zone-refining, for example, it is possible to follow progressively the movement of impurities along the bar. In a bar of silver having $\frac{R_{4 \cdot 2}}{R_{273}} = 0{\cdot}003$ as ingot, the value fell to 0·0013 at one end and rose to 0·006 at the other end after zone-refining, showing how the impurities had been moved along during the process.

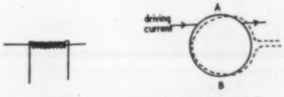
SUPERCONDUCTIVITY

Needless to say, the practical applications of superconductivity are not connected with the loss-less transfer of electric power. The uses of superconductivity are much more subtle, and indeed more interesting than this. It is convenient first to summarize some of the relevant properties of superconductors: (i) A superconducting metal has zero resistance and a current started around a closed loop of superconductor will persist indefinitely, provided the metal remains superconducting. (ii) Superconductivity can be destroyed by a magnetic field above a certain critical value, or by a current above a critical value. (iii) A magnetic field cannot enter the body of a piece of superconductor, which is a perfect diamagnetic. (iv) The magnetic flux through a closed loop formed by a piece of superconductor remains constant as long as the metal remains superconducting.

Some of these properties are employed in striking laboratory demonstrations. A well-known example is the "floating magnet." Here a magnet floats above the surface of a superconductor, being held up, so to speak, by its image in the diamagnetic material. Or a sphere of superconductor may be made to float above suitably arranged rings of a superconductor, being held up by the magnetic action of persistent currents in the sphere and rings. Indeed, these two devices have actually been found uses: the floating sphere in the measurement of the viscosity of helium gas—by observing the rate of damping of the sphere set in rotation—and the floating magnet as the basis of a suspensionless galvanometer.

One of the most interesting uses of superconductivity is in the superconducting bolometer. If a bolometer made of a superconducting metal is maintained at its transition temperature, a minute influx of radiant energy will cause a substantial increase in temperature, because of the very low specific heat of metals at these temperatures, and this will cause a relatively large increase in resistance because of the steepness of the transition curve. This type of bolometer was seriously considered during the war for the detection of aircraft as an alternative to radar, and it is now being used in spectroscopy. Its sensitivity is intrinsically very high and, because it is essentially a low temperature device, noise arising from the instrument is very small. Indeed, for work in the very far infra-red, it is probably the most promising of existing detectors.

Better known are certain devices making use of the electrical and magnetic properties of superconductors for switching or " memory " elements of the types used in digital computers. One of the simplest is the "cryotron," illustrated in Figure 3a. This consists simply of a piece of one superconducting wire wound around another. They are made of different metals so that when maintained at a convenient temperature the coiled wire can remain superconducting even if it passes a current sufficiently large to destroy—by its magnetic field—the superconductivity of the straight wire. It is clear that by adjusting the current through the coiled wire the straight wire can be " switched " in and out of the superconducting state. Two cryotrons in series, with suitable connections, can, for example, be made into a bi-stable system or " flip-flop." It was soon realized that it would be possible in principle to build a digital computer, using devices of this kind, which would dissipate only very small amounts of energy. A complete computer might be housed in a vessel about the size of a domestic Thermos flask, dissipating less than a watt.



(a) cryotron (b) use of trapped flux

Fig. 3. (*a*) *Cryotron.*
(*b*) *Use of trapped flux.*

Another family of devices based on superconductivity makes use of " trapped flux." A simple example is illustrated in Figure 3b. Here the driving current divides between path A and path B so as to leave the flux through the ring unaltered, whatever the value of the current.

However, when a certain current is reached path A becomes non-superconducting and all the current is diverted into path B. The flux through the loop then changes suddenly. A second loop (broken line) linked inductively with the first will detect this sudden change.

At first these superconducting devices were somewhat slow in action as compared with thermionic valves and transistors. More recently, however, their speeds have been greatly increased, and devices in which the working elements are thin evaporated films are now designed to operate in times well below a micro-second. There is obviously very liberal scope for the imagination in this new field of electronic technique and it will not be at all unexpected if we hear, in the not too distant future, of rockets which contain their own electronic computers.

MAGNETIC INTERACTIONS

Finally, we come to a family of devices which make use of the phenomena studied at the very bottom of the left-hand panel in Figure 1—the paramagnetic interactions between atoms in molecules or in solids. An example is the " Maser "; the term stands for " microwave amplification by the stimulated emission of radiation "—a succinct definition of the function of the device.

The underlying idea is as follows: at thermal equilibrium the probability of induced emission and absorption between two atomic energy levels due to an exciting field are equal. However, if in some way the upper level can be caused to be more heavily populated than the lower there will be an excess of emission and under suitable circumstances this can lead to amplification. The most promising—though not the earliest—approach is to use magnetic transitions of electron spins in the solid state, and the exciting field is then magnetic. There are usually great advantages in working at liquid helium temperatures; one reason has already been suggested in another context: the excess population of the upper level in the " two-state maser " described is proportional to $\frac{h\nu}{kT}$ and thus higher at low temperature. However, there is another important reason; before the appropriate non-equilibrium distribution of atoms among energy states can be achieved it is necessary that some at least of the relaxation times which characterize the interaction between the electronic (or nuclear) spins and the lattice should be large. This condition is favoured at low temperature, where the lattice interactions are of smaller amplitude.

In the journal of a less sober society this application might have come under the title " Uses of Negative Temperatures " since the inverted distribution among atomic energy states can be regarded as defining a " negative temperature " for a part of the system. It is of course a misnomer since the concept of temperature relies upon the capacity of a system to come into equilibrium with other systems. We are still—and always shall be—limited to positive temperatures, but it is very striking that practical applications of temperatures in the range 1°-4°K now exist and that they depend upon an understanding of the phenomena characteristic of even lower temperatures. It is difficult to predict the future: the writer is already astonished by the difference in emphasis between this lecture and one given under roughly the same title only three years ago.

ANNUAL DINNER

Members who still require tickets for the Annual Dinner, which is to be held at the Park Lane Hotel, Piccadilly, London, on Tuesday, May 3, should return application forms immediately. Extra forms may be obtained from the Secretary.

Any members requiring hotel accommodation are reminded that early booking is particularly important in view of the wedding of H.R.H. Princess Margaret on May 6.

Practical Work in Solid State Physics

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[A talk presented at a Conference for teachers in courses for the National Certificates in Applied Physics, held at the Institute's House on October 22, 1959.]

In this talk I should like to use, as an example to bring to life certain general problems of laboratory teaching in physics, our work in Rugby in designing a solid state physics course, for the Higher National Certificate in Applied Physics. The lecturer on legal matters refers to special cases to bring home more vividly the result of applying wide legal principles. I intend to describe some of our practical work and thereby emphasize some of the problems we have had to face. Just as legal case histories are often absorbing in themselves, so also, I hope, some of our experiments are not without their own interest.

I should like to bring three important questions to your attention. Firstly, how much time should be allocated to practical work? Secondly, what plan should be followed in selecting the experiments? There are two points here : (*a*), what criteria can be applied to the suitability of experiments and (*b*), what sources can be scanned for ideas? Thirdly, how should the practical work be organized?

Our Higher National Certificate students work for two years, spending ten and a half hours per week on organized learning throughout the whole period; that is, one day and two evenings. For the remainder of each week they work in various sections of the Research Laboratory of a large electrical engineering firm.

First consider how much time ought to be devoted to practical work. Let me declare my prejudices at the outset. I believe that laboratory work in physics is of immense value to the students. I hardly think it is possible to allocate too much time to the laboratory. The more time is available, the more the students can, with guidance, act as explorers on their own. The less time is available, the more cut and dried the experiments must become and the less the opportunity for the students to verify sufficient facts and to find out the art of experimentation for themselves. But we have to be realists, and it is apparent from the H.N.C. timetable shown in the first table that the teacher of solid state physics has to be content with one hour per week for the lecture course and three hours per week for one term for the practical course, during each of the two years.

Note that the listed time of 2½ hours for practical work is a weekly average. In fact all physics laboratory periods consist of three hours—the very minimum. I have noticed that other colleges sometimes list extremely short laboratory periods. One hour or even one half hour is not unknown, and I find it hard to understand how physics students can derive anything useful from such a rushed exercise. Possibly the explanation is that in these cases also the time-table shows a misleading weekly average.

TABLE I
TIMETABLE FOR H.N.C. IN APPLIED PHYSICS
(2-YEAR COURSE)

For each year we have:

	Theory	*Laboratory*
Physics	1	2 hours
Applied Physics		
Solid State	1	2½ hours
Electronics *Vacuum Physics	1	
Mathematics	2	
Tutorial	1	

* *Note.* Electronics theory runs for 2/3 of the session and vacuum physics for the remaining 1/3 of the session.

Many of our experiments, as I shall mention later, require more than one three-hour period to carry them out, with a proper degree of cogitation on the subject and a proper exercise of initiative concerning the experimental work. In such cases, arrangements are made for the student to continue with his experiment for a second three hours, so that he can make a satisfactory job of it. A few experiments well done and in which the student has shown a little originality, are worth many formal experiments done in a rush.

The second of our general problems concerns the selection of experiments. The devising of an experimental course on solid state physics is made easier by following some clear principles. The ones we have tried to adhere to are these.

(1). The experiments must be closely related to the theoretical course. Each of the main fundamental measurements discussed in the lectures should, if at all feasible, be available as the basis of an experiment. Preparation of the main types of material of theoretical interest gives many absorbing experiments. Here it is noteworthy that it doesn't pay to be inhibited by doubts about the exact classification of some of the experiments. Preparation of a semiconductor or of a Heusler type of magnetic alloy may be damned by some people as being metallurgy, chemistry or at any rate not physics. I think this is a short-sighted view. These preparations form worthy scientific experiments for inclusion in a course on solid state physics. The materials which the students prepare can be taken as the raw material on which to perform measurements of physical properties. Alternatively, commercial material may be used.

(2). The main inspiration for experiments on a subject like solid state physics must be the literature. It is axiomatic that the teacher must study the literature as intensively as possible, always searching for experiments simple enough and clear cut enough for the students to perform. Some contact with the industrial users of solid state physics is helpful and must be made and fostered by means of works visits and otherwise. It is very difficult to try to teach an applied physics subject without any knowledge of the relevant industry. The industrial experts may well be happy to suggest some excellent experiments.

(3). Simplification of experiments is almost always a desirable thing. Besides making it easier for the student to extract the essence from an experiment, simplification is absolutely necessary if experiments are to be completed within three or six hours.

Now let me describe some of our experiments to illustrate the points I have made. Some of them are extremely simple but they are, in the main, away from stereotyped lines. The experiments are presented in relation to the theoretical course on solid state physics which the practical work is designed to illuminate. An outline of the syllabus is given in Table 2. It can be seen that the course includes a brief discussion of the main physical theories underlying the mechanical, electrical and magnetic properties of materials, together with some necessary fundamental physics, such as the sections on crystallography and on X-rays.

TABLE 2
H.N.C. SOLID STATE PHYSICS
OUTLINE OF SYLLABUS

Atomic structure and the periodic table of the elements.
Fundamentals of crystallography.
X-rays: production, properties and X-ray diffraction.
Dislocations in crystals, crystal growth.
The mechanical properties of crystals, dislocation theory.
The magnetic properties of materials; brief account of theories of magnetism.
The electrical properties of materials; the physics of semiconductors; the physics of dielectric materials.

Consider experiments on crystallography. There is no doubt that a number of standard crystallography exercises ought to be performed by the students. The main problem is that crystallography tends to be rather time-consuming and this must be overcome by simplification and modification of the experiments.

We have an experiment in which the students grow and examine crystals of each of the seven crystal systems. For simplicity the crystals are grown from aqueous solution and for speed the crystallization is carried out on a microscope slide. Within a few minutes the growth of microscopic crystals can be watched as a few drops of warm saturated solution cool on the slide. All the crystal systems can be grown and sketched within a few hours. As an extra means of observation polarized light is employed.

Indeed, a number of exercises on polarized light are included amongst the crystallography experiments, as set out in the third table. As you can see, the experiments culminate in the use of the Babinet compensator for the analysis of polarized light.

TABLE 3
EXPERIMENTS ON POLARIZED LIGHT

1. Some experiments with plane polarized light, including rotation of the plane of polarization, polarization by double refraction and the measurement of the two refractive indices for a doubly refracting prism.
2. Experiments on circularly and elliptically polarized light and its analysis by quarter wave plate.
3. The production of bands in the Babinet compensator and the calibration of the instrument.
4. The analysis of polarized light using the Babinet compensator.

We feel that these experiments should be available for interested students since polarized light is an important tool for the detailed study of crystals. Furthermore, its use is becoming widespread for other purposes in solid state physics. Examples are the observation of magnetic domains, the measurement of corrosion, the study of preferred orientation in polycrystals and the micrographic examination of some of the materials used in the production of nuclear energy.

One cannot afford to dispense with an experiment in which the optical goniometer is set up and used to measure the angles between the faces of a macroscopic crystal grown from solution. The difficulty in presenting results without spending a lot of time studying the stereographic projection is overcome by confining measurements to one zone. For simplicity a single, horizontal-circle instrument is used, a well-defined zone is chosen and the angles between its faces are measured. A collimator gives a beam of parallel light which is reflected from the crystal and received as a signal in a telescope whenever the normal to a reflecting face bisects the angle between the collimator and the telescope. The zone axis of the crystal is at right angles to the plane of the telescope and collimator. The crystal is

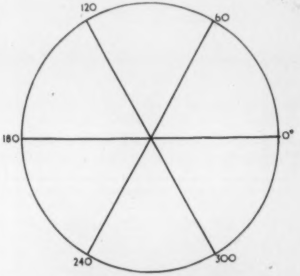

Fig. 1. *Results for a zone with hexagonal symmetry.*

rotated and the angles at which the different faces of the zone give reflections are simply marked on a circle. In Figure 1 the resulting diagram is shown for a zone with hexagonal symmetry, the reflections occurring at angles of 60°.

The plan of symmetry of the crystal zone can be discovered and, by repeating measurements on a number of crystals of the same species, the law of constancy of crystal angles can be verified. Thus the main results which (historically) were derived from goniometry are substantiated by our students within a fairly short time, this being accomplished without the need for them to have facility in thinking about crystals in terms of stereographic projections. The need for accuracy in measurement and care in setting up is not jettisoned so that the experiment remains a useful exercise.

The experiments on magnetism emphasize some further points. The preparation of a rudimentary Heusler alloy, a ferromagnetic alloy of non-magnetic elements, is quite simple to carry out and yet affords an apt illustration of the theory of ferromagnetism.

The magnetism of substances must, of course, be attributed to the magnetic moment of the atoms or molecules arising from the addition of the moments of the constituent electrons. Many elements have appreciable atomic magnetic moments but it is only in favourable cases in the solid state when the atomic moments are all aligned parallel to one another so that ferromagnetic domains are produced. For ferromagnetism to occur the atoms of the solid should be spaced apart quite widely. This can be seen in Figure 2, in which exchange energy is plotted against the ratio *R*/*r*, where *R* is half the separation of the atoms in the solid and *r* is the radius of the unfilled shell of electrons which is responsible for the magnetic moment. In effect a positive value of the exchange energy means that the ferromagnetic domains are stable and negative exchange energy means that domains do not form. It can be seen that the exchange energy depends on the distance apart of the atoms and is only positive when *R*/*r* is greater than 1·5. Therefore those elements are ferromagnetic for which the value of *R*/*r* lies on the upper part of the curve and in this category we have iron, cobalt, nickel and gadolinium. For some elements such as manganese the interatomic spacing in the crystal is too small for ferromagnetism to occur but the atoms can be pushed apart by suitable alloying, when the resulting substance becomes ferromagnetic. The famous Heusler alloys are of this type.

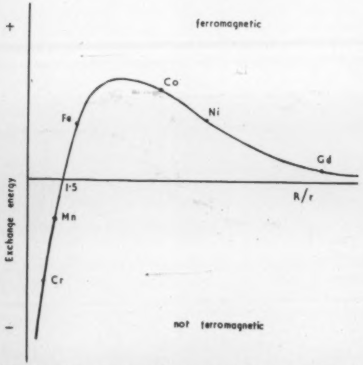

Fig. 2. *Curve showing exchange energy for various elements, plotted against the ratio of half the atomic separation to the radius of the unfilled shell.*

Our students verify that it is possible to make a magnetic alloy of non-magnetic elements by preparing a specimen of the ferromagnetic alloy of manganese of composition Bi Mn, the atoms of bismuth being particularly suitable for pushing the manganese atoms apart. After having appreciated the aim of the experiment, different students have chosen different methods of making the bismuth-manganese alloy. For practical suggestions concerning this type of work we are very glad to have the help of a metallurgist. The Bi Mn specimens are strongly ferromagnetic and by casting suitably shaped test-pieces, measurements of physical properties can be made in subsequent weeks, following standard experiments. The actual preparation can easily be carried out within a three-hour period and serves to imprint the theory on the students' minds in a vivid manner.

The mixed oxides known as ferrites (of chemical composition MO Fe_2O_3 where M is any divalent metal such as Mg, Cu, Mn or Ni) form another type of magnetic material which is easily prepared by the students. The ferrites are, of course, non-conductors of electricity as opposed to most other common magnetic materials which are metals. The high electrical resistance of the ferrites means that they have low eddy current loss, an advantage which is pronounced at high frequencies.

To prepare a ferrite, the powders of ferric oxide and the other chosen oxide are mixed in the proportion of their molecular weights and pressed into the shape of a toroid or bar, whichever is required for subsequent physical testing of properties. The specimen is then heated in a furnace. The commercial technical literature gives a good guide to the heat treatment. On removing the specimen from the furnace and cooling it, the ferrite becomes strongly magnetic. Some of the applied physics students have been quite enterprising, and having made a simple ferrite and verified that it does indeed have the expected combination of properties, they have tried their hands at making mixed ferrites or at finding the effect of variations in heat treatment.

Two different methods have been used to obtain the Curie temperature of the ferrites. If a toroid can be made successfully then a primary and secondary winding can be put onto it and connected as for a B/H loop determination, with a ballistic galvanometer in the secondary circuit. If the toroid is placed in a furnace and readings of ballistic galvanometer throw against temperature, for reversal of the primary current, are obtained, then a curve is given as shown in Figure 3.

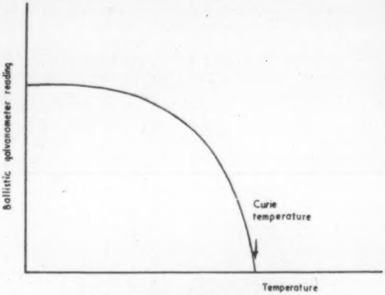

Fig. 3. *Curve showing Curie temperature.*

The Curie temperature, at which the quasi-ferromagnetism vanishes, is clearly visible. This experiment has often been bedevilled by cracks in the toroid or by the difficulty of winding the primary and secondary, suitably insulated to withstand the temperatures involved.

We have had a great deal more success with a method suggested by a visitor to the laboratory. A bar of the ferrite is prepared and suspended in a furnace in the magnetic field due to two bar magnets. In equilibrium the ferrite bar is aligned (horizontally) with the magnets.

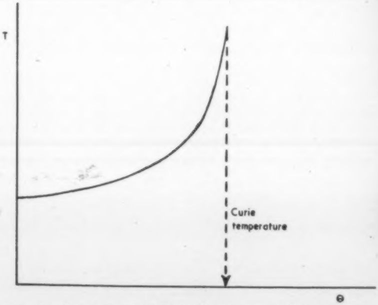

Fig. 4. *Curve for Curie temperature by an oscillation method.*

The method consists of timing the period of oscillation, T, of the sample in the horizontal plane as the temperature, θ of the furnace is raised.
We have:

$$T = 2\pi\sqrt{\left(\frac{I}{MH}\right)}$$

where I is the moment of inertia of the sample,
M is the magnetic moment of the ferrite bar
and H is the magnetic field.

As the temperature is raised, the magnetic moment falls and therefore the period increases, as shown in Figure 4. The Curie point is the temperature at which T increases most steeply. T does not increase to infinity as M falls to zero since the elasticity of the suspension also exerts a restoring couple on the ferrite bar, even when the magnetic couple has vanished.

There are many other exciting possibilities for applied physics experiments along these lines.

In the Science Department at Rugby a strenuous effort is made to ensure that all the teachers do some research work. However modest this work may be, it is almost bound to afford some suitable experiments for the students. This is because the research is appropriately integrated with the general work of the department. Rather diffidently I should like to mention one possibility which illustrates the point. I have been interested in the wonderful pictures of Roberts and Bean* showing magnetic domain patterns. The method of observation uses polarized light. It would be too ambitious to ask H.N.C. students to repeat the work of Roberts and Bean but, having obtained magnetic domain patterns myself in polarized light (see Figure 5) and having found out the various snags and difficulties, I have no doubt whatever that the students could be guided to observe magnetic domain patterns themselves. If they could do so, I'm sure it would help in making the theory of magnetism seem more close to reality.

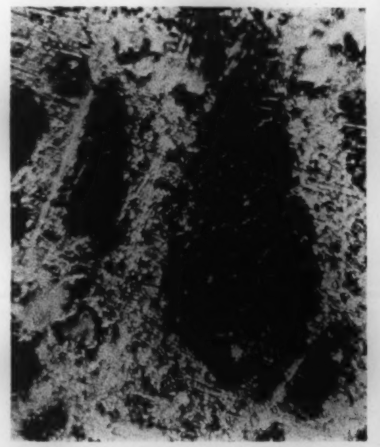

Fig. 5. *Domains in a Bi Mn specimen observed in polarized light. The whole area under observation is about one twentieth of a millimetre across.*

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* B. W. Roberts and C. P. Bean, *Phys. Rev.*, **96**, 1494 (1954).

One last example from our experiments is of a different type again. In the theoretical section on semiconductors the process of zone refining for purification of silicon and germanium is bound to be described. Probably no theory is given and there is no mention of segregation coefficients. The zone refining of a semiconductor at a temperature in the region of 1200°C is an expensive, slow and technically difficult process. Dr. Wignall suggested an experiment on purifying an organic material by zone refining; for instance, anthracene or naphthalene contaminated by a blue dyestuff. Since the temperature which is necessary is only in the region of 100-200°C, very simple apparatus can be used along the lines of that described by Parr.† The material is contained in a simple glass tube and surrounded by a heated wire element which is slowly moved downwards. A narrow molten zone is produced in which the impurity is swept along and concentrated. The whole experiment, making several refining passes, can be completed within three hours. The blue dye is then seen to be concentrated within a narrow band. Comparative fluorescence under ultra-violet light is also used to test the efficiency of the zone refining passes. The experiment affords an opportunity for giving the students a brief account of the theory of zone refining, as dependent on the equilibrium diagram of the binary system under consideration.

This concludes what I wish to say about the selection of experiments. I have tried to illustrate some criteria which can be applied to the suitability of experiments and to show the diverse sources from which experiments can be selected.

The final group of problems are those connected with the organization of the practical work. We have tried to arrange that, for H.N.C. practical work, the students work individually or at worst in twos. Also they can go at their own pace, giving time for thought and experiment in overcoming difficulties. This spells death to the system of arranging cycles of experiments for the laboratory, with students moving from one experiment to the next week by week. In our system the student can linger over an experiment for another week if he wishes and other students must do something else rather than take over his apparatus. Thus the teacher must have plenty of elbow room in apparatus and ideas to provide extra experiments.

There are groups of related experiments, for instance on magnetism or polarized light. A student may do just one experiment of a group or, if he is particularly interested, he may do several associated experiments, thus specializing a little. One student may specialize on magnetic materials and another on semiconductors. Even if a given student does only one magnetic preparation, he probably comes along to admire the magnetic Heusler-type alloy made by one of the others. In a small enough group the students can educate one another quite well in this way.

For each experiment a duplicated laboratory instruction sheet is provided, giving theory and an outline of the method and alternative methods if any. The laboratory instruction sheet is the property of the student, to take home with him and study at leisure. A filing cabinet is an essential piece of equipment to keep the laboratory instruction sheets readily accessible.

Plenty of space in the laboratory can help organization. Ideally the experiment sites should be more or less fixed in position and the students should circulate round the laboratory, from one experiment to the next. This reduces the amount of effort which need be devoted to putting apparatus away in cupboards. Surely this should not be necessary except with minor items such as thermometers and ammeters. In addition, special parts of the laboratories must be set aside for special tasks. Our needs are met by sections for microscopy, photography, heat treatment, spectroscopy, chemistry, magnetism, vacuum physics and optical work, in addition to a spacious area for general work. For other laboratories in which the emphasis is on other subjects the requirements would, of course, be different.

These new applied physics courses which are coming into being do provide a wonderful challenge to those who are teaching them. Experiments can be found which are of quite a novel type, which are in touch with modern technical progress and which yet have a sound physical and scientific content.

Lastly, I should like to stress that the experiments about which I have talked are the result of team-work within the entire Science Department at Rugby, under its Head, Dr. J. S. Wignall, and I wish to thank my colleagues who have let me talk about some of their experiments.

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†N. Parr, *Zone Refining* Royal Institute of Chemistry Publication, p. 19 (1957).

Education for Automation

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O.B.E., M.A., M.I.E.E., F.Inst.P.
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[Based on an address given to the Education Group of the Institute on November 25, 1959]

THE REQUIREMENTS

The *Annual Abstract of Statistics 1958* shows that there were 24,000,000 workers in this country of whom 20,000,000 were employed full time. These employees were distributed as shown in Table 1, from which it is seen that at least half were employed in industries which are very much dependent on the application of automation (in which we will include all types of improvement of manufacturing processes) if they are to compete with the U.S.A. and the U.S.S.R. in world markets.

TABLE I

Estimated Numbers of Employees — 1957

1. Manufacturing industries ...		9,271,000
2. Other industries very dependent on automation:		
Mining and quarrying	868,000	
Gas, electricity and water supply	379,000	
		1,247,000
3. Industries partly affected by automation :		
Agriculture, forestry, fishing ...	1,025,000	
Transport and communication	1,723,000	
Distributive trades	2,945,000	
Insurance, banking and finance	509,000	
Building and Contracting ...	1,519,000	
		7,721,000
4. Services almost entirely unaffected by automation :		
Public administration ...	1,298,000	
Professional services	1,896,000	
Miscellaneous services	1,812,000	
H.M. Forces and Women's Services	702,000	
		5,708,000
	Total	23,947,000

In the more advanced industries in this country as well as in the U.S.A., at least one-tenth of all the employees are qualified scientists and engineers and although the Committee on Scientific Manpower has found that some of these industries over-estimated their requirements, there can be little doubt that about one in ten employees should be fully qualified. In the basic industries, such as steel-making and cement manufacture, the proportion of unskilled labour is diminishing owing to the application of automatic handling methods and until recently these industries have had little experience of using qualified engineers and scientists so that, in general, they are likely to under-estimate their future requirements of trained engineers. Taking all these considerations into account, it is reasonable to suppose that in those industries dependent on automation, which we have seen employ approximately 10,000,000 full time workers, 5% of this or 500,000 should be fully qualified engineers and scientists. Further, since we know that in the U.S.A. and the U.S.S.R. the proportion of qualified engineers and scientists has already far outstripped ours, we need to reach this total figure as quickly as possible. The estimated number at present employed is 150,000 and so, in order to do this, we need an annual output of qualified technologists of at least 25,000 a year. Even so, it will take more than ten years to reach the target of 500,000, by which time there is reason to believe we may need a million.

It is generally reckoned that each technologist needs to be backed up by four or five technicians. It is always difficult to agree on the definition of a technician, but I am going to assume that he is a man with technical training in some limited field of technology, who is capable of carrying out routine technical work in that field without direct supervision and who is expected to carry some responsibility, either technical or executive, but is not expected to introduce new ideas or techniques. In highly automated industries the category of technician will include :

1. Installation engineers
2. Maintenance engineers
3. Plant operators
4. Charge hands and foremen
5. Test operators (both for laboratory tests and quality control)
6. Draughtsmen.

With the introduction of automatic machines, the number of skilled craftsmen is likely to remain constant or fall and we have seen that the number of semi-skilled and unskilled workers is certainly being reduced. Thus, it can be assumed that approximately 2,000,000 technicians are required in the near future and this will gradually increase to at least 3,000,000. The increase will presumably be recruited from those who are or who would previously have been craftsmen, any deficiency in the latter class being made good from the lower cadres of semi- and unskilled workers.

This gives the percentages of the various cadres of workers as given in Table 2, which also gives the limits of the intelligence quotients available as indicated by the I.Q. curve of Figure 1. It is appreciated that intelligence quotient, as measured, may not be of great relevance in this connection but if we take some other measure of ability, call it capability factor or what you will, the distribution in the population is certain to be Gaussian and the curve will by definition be the same. It will be seen from Table 2 that there should be no difficulty in recruiting technologists of adequate ability but, when we come to technicians, recruitment will

TABLE 2

Category	*Total number employed*	*Percentage of total employees*	*Limits of I.Q. Group available*
Technologists, including Managers and Senior Sales Staff ...	1,000,000	10	$\geqslant$ 120
Technicians, including Junior Sales Staff	3,000,000	30	107—120
Skilled workers	2,000,000	20	100—107
Unskilled and semi-skilled	5,000,000	50	$\leqslant$ 100

certainly have to go down to I.Q. 110 and probably to 107, which will certainly result in very serious problems of training.

TRAINING

(*a*) *Technologists*

It is probable that the facilities now being provided in universities and technical colleges will prove adequate to train the 25,000 technologists required each year, provided suitable students can be selected. There is considerable evidence that, at the present time, although all science and engineering students could be trained from the top 10% with I.Q. $\geqslant$ 120 and still leave an equal number of I.Q. $\geqslant$ 120 for the other professions, our selection mechanism results in it being impossible to fill the classes already available with students of adequate calibre. It is probable that in the past, the normal school-leaving age of 15 has been responsible for this and it may well be that the change in fashion resulting in many more staying on at school until 17 or 18 will gradually improve the position.

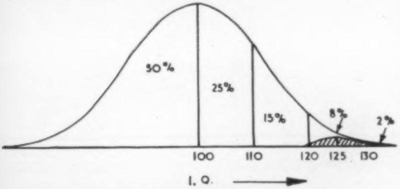

Fig. 1. *The distribution of intelligence in the population. The shaded area represents the distribution for university students.*

(*The figures are approximate and derived from a variety of sources.*)

As manufacturing plant becomes more automatic, the design of product and plant become ever more dependent on one another, and for automation to be successful the design of processes and manufacturing plant must be closely integrated. The control engineer must work in close harmony with the product designer and the range of engineering and technology to be covered is enormous. Also the problems to be overcome in introducing automation in industry are mainly those of application, which cannot easily be taught in the classroom and teaching laboratory. On the other hand, in some cases success can only be achieved by the use of the most advanced techniques. In general, it is only as members of teams developing major projects that young engineers can learn to apply successfully the theory and techniques that they have learned in the teaching institutions. An engineer designing automatic plant must be well versed in the principles of mechanical engineering, but since many problems are far more economically carried out electrically, he must also grasp the fundamentals of electrical engineering. The design of automatic plant must be entrusted to a team including mechanical, electrical and electronic engineers, and frequently mathematicians, chemical engineers, physicists and chemists. If the most appropriate techniques are to be used, some members of this team must have been trained as control engineers, with a good fundamental knowledge of electrical, mechanical and chemical engineering as well as a wide knowledge of measurement and control. No one man can become experienced in all the techniques required in automation, but if he is going to direct the work of others, he needs to know enough about them all to discuss the pros and cons of different techniques without being prejudiced against any one because it is unfamiliar.

The great difficulty in training technologists for industry is therefore that most of them require to be engineers at heart but in order that they can be versatile they must have an extremely good background of physics. Most of them need a good background of the fundamentals of physics and mathematics, of mechanical and electrical engineering, of hydraulics and of some chemical engineering. In the factory they need the ability to solve practical problems which may involve both technical and human considerations. Fifty years ago almost all the technical problems would have been mechanical but now there are likely to be as many electrical problems as mechanical and no matter whether a man is trained as a mechanical engineer or an electrical engineer, he must be able to deal with both aspects. If, when he qualifies, whether it be as a mathematician, physicist or engineer, he is going to do research in any advanced field, whether in electronics, aeronautics, nuclear power or control engineering, he will need the same mathematics and physics. Surely, therefore, it is time to get rid of the classical divisions of engineering and to give students the option, not of reading aeronautical, chemical, civil, electrical, mechanical or nuclear engineering but rather, of production engineering or research, in which case they would probably decide on whether or not they have an aptitude for mathematics and theoretical reasoning or for the solution of practical problems.

If this were done, it would have the great advantage that the student would not have to commit himself to one branch of engineering early in his undergraduate career but, starting with a basis of fundamental physics and mathematics, would be able to take a specialization by biasing his attention on those aspects of technology in which he was most interested.

(*b*) *Technicians*

In order to build up and maintain a force of two to three million technicians, we need an annual output of at least 100,000. However, since at the present time there are about 400,000 part-time day students in our technical colleges, this should be possible. The difficulty lies in developing suitable curricula for students, the I.Q. of whom may be as low as 107. It is usually considered that technicians are only capable of acquiring knowledge over a fairly narrow field but in the maintenance departments of big factories and chemical plants, for example, technicians are responsible for and have to service a very wide range of instruments and equipment. Now that the Diploma in Technology is to become the standard qualification for the professional technologist, the Ordinary and Higher National Certificates will presumably become the accepted qualifications for the technician but the way must be left open for the brighter technician, who has attained a Higher National Certificate, to proceed to a professional qualification.

Therefore, as for technologists, we again reach the conclusion that technicians need a good foundation of physics, mechanics, some mathematics and a little chemistry, but taken, of course, only to a much lower level to make a suitable foundation for specialized courses. If the syllabi for the Ordinary National Certificate courses in applied physics, electrical engineering and mechanical engineering are studied, it is found that 90% of the material is common and many physicists and engineers in industry and on the staff of technical colleges are of opinion that the time has come for a common Ordinary National Certificate on which Higher National Certificates in applied physics, electrical engineering, mechanical engineering, instrument technology and other specialist courses could be based. The Society of Instrument Technology has, in fact, prepared syllabi for such a course and these were discussed at a conference held in London in September, 1959. It had been hoped to compress all the material into the specified time of three periods a week for three years by re-arrangement of the physics courses to provide more logical curricula in the light of modern physics. The basis of this re-arrangement is that in the first year there should be a course entitled " Structure and Properties of Matter " to be followed in the second year by a course entitled " Mechanics and Energy." In this way, such general topics as wave motion would be treated once instead of under the separate headings of heat, light, sound and electricity. These two courses would cover all the physics and mechanics except for some geometric optics and electricity and magnetism, which would be dealt with in the third year. The Conference felt that this re-arrangement would introduce very severe problems of teaching in technical colleges at the present time and could not agree that there would be any saving of time, but the universities are already thinking along similar lines for their elementary courses and so also, I believe, is the Science Masters' Association for students taking G.C.E. and I feel sure that in a few years' time we shall agree that this is the proper way of teaching physics at all levels.*

I have no doubts at all that the majority of technicians will need the sort of grounding provided for in these syllabi, but certainly there may be great difficulty in teaching physics to students of low I.Q. in this manner. For, of necessity, the approach is rather idealistic and theoretical and it may be extremely difficult to keep up a student's interest, unless practical examples can be given from every-day life or, better, from the industry in which he is working. I suggest that, at the present time, we have relatively no experience of teaching basic physics to students with I.Q. below 113. I do not believe there will be much difficulty in devising suitable syllabi for a Higher National Certificate course, provided we can perfect the Ordinary National Certificate course. One more advantage of having a common Ordinary National Certificate would be that since all students taking Higher National Courses would have the same background, it would be far easier than at present to amalgamate classes for courses common to two or more Higher National Certificates.

Although this may be unpalatable in these circles, it must always be borne in mind that the vast majority of apprentices in industry are in engineering departments and look forward to an engineer's career rather than a physicist's. They therefore feel they need an engineering qualification and wish to work towards it. The great problem is now to satisfy this desire and at the same time ensure that they learn as much basic and applied physics as they will need.

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* The proposed syllabi and the discussion on the desirability of a common Ordinary National Certificate will be found in the Proceedings of the Conference, which may be obtained from the Secretary of the Society of Instrument Technology, 20 Queen Anne Street, London, W.1.

Notes and News

Fortieth Annual General Meeting

Notice is hereby given that the Fortieth Annual General Meeting of The Institute of Physics will be held at 5 p.m. on Tuesday, July 5, 1960, at the Institute's House. Attendance is limited to Fellows and Associates of the Institute. The business to be conducted is the consideration of the Board's report and the accounts and balance sheets for 1959. A copy of the annual report and accounts is printed in this issue of the *Bulletin*. Further copies will be sent on request.

F. A. VICK,
April 12, 1960. *Honorary Secretary.*

The Institute's Finances

The consolidated accounts on pp. 99-100 of this issue of the *Bulletin* are as usual issued for the convenience of those members who wish to have a simple general picture of the Institute's financial affairs as a whole. These combine the formal accounts of the Institute proper (on pp. 123-124), and its Endowment Trust Fund (on p. 125) through which the scientific and educational work is carried out. The formal accounts will be presented for adoption at the Annual General Meeting.

The accounts show how fully justified the Board was in proposing the increases in members' fees and in the subscription rates to the Journals which became effective on January 1 ; for, it is clear that, without these there would have had to be a serious deficit and probably a severe curtailment of the Institute's activities. As it is, however, it has been possible with careful budgetary control to finish the year with the very modest final surplus of £656 on a turnover of some £70,000.

It is gratifying to note from the Annual Report (p.112) that the number of members resigning or removed from the register is still extremely small in spite of the increase in members' fees.

The surplus on the year's working was £1,321 less than the budgeted surplus, and this is mainly accounted for by essential additional but unforseen expenditure on the House. Most of this additional expenditure was due to the conversion of the mews premises ; such expenditure is now paid from income, instead of being written off over a number of years as is still being done with the original heavy expenditure incurred when the House was first occupied.

While the income from members' fees and Journal subscriptions was better than the estimates, that from advertisement revenue was considerably less ; this was partly due to the serious strike in the printing industry which affected all periodicals in this way.

Beyond the items already referred to, the expenditure side of the accounts call for no special comment beyond noting the steady increase in most items caused by increasing numbers of members and in the activities of the Institute coupled with further increases in the cost of labour and materials particularly in the printing industry.

The proposals (referred to last year in these notes) for obtaining the necessary additional financial support to enable the Institute's work to grow in the way in which the Board is sure members desire, are being examined by the new Council of the amalgamated body "The Institute of Physics and The Physical Society."

The postgraduate training of physicists in British universities

A report on the postgraduate training of physicists in British universities, prepared by a joint committee appointed by the Institute and The Physical Society, is now available. The committee consisted of Prof. N. Kemmer (*Chairman*), Dr. R. Beeching, Prof. R. V. Jones, Mr. J. A. Ratcliffe, Mr. L. Rotherham, Dr. R. W. Sillars, Dr. R. A. Smith, Prof. D. H. Wilkinson, Prof. J. G. Wilson, and Mr. N. Clarke (*Secretary*). It took evidence from employers, heads of government departments and members of university staffs.

The report ends with the following conclusions :

"1. For its purpose, which is fundamentally the introduction of an undergraduate to the procedure of fundamental research, working for the Ph.D. is an admirable training. It is essentially a training for subsequent research, and for men who possess the requisite qualities of originality and high intellectual ability, it can produce technical accomplishments and the right mental attitude for successful fundamental research in industrial or other laboratories. If it is to retain its value as a hallmark of capacity for original research, the universities must be jealous of the high standard of those on whom it is conferred.

2. The research student plays an important part in maintaining the vitality of a university physics department. Without a sufficient number of these students it would not be possible to maintain the output of fundamental research which has now become accepted as appropriate to a university department ; nor would it be possible to retain or recruit academic staff of suitable calibre. Moreover, research activity has important influence on the educational atmosphere of the university. The universities, however, must not seek expansion of research activity without limit and they must ensure, which is not always the case at present, that research students are not employed partly as high-grade technicians. This is a particular difficulty when the nature of a department's main research interest is such that students are organized in teams.

3. The standard of the Ph.D. in physics is at least as high as in most other subjects but the degree is sometimes (and, in the opinion of some employers, often) awarded to candidates of inadequate calibre. This is a serious criticism of what is apparently the universities' willingness to lower the status of their own degrees.

The universities should be more critical in their selection of research students and more willing to refuse the award, even after the completion of the prescribed period of study and research. There is a strongly held opinion among employers that the standard of the Ph.D. has deteriorated significantly in the past 20 years ; the remedy for such an impression lies entirely within the power of the universities.

4. Industry needs physics graduates of wide knowledge, adaptability and first-class intellectual capacity and would prefer that only a small proportion of its recruits had had research training for a Ph.D. in a university. Graduates with the Ph.D. are often sought only because of the qualities they displayed in their undergraduate course and examinations and for these men their employers consider the Ph.D. to be irrelevant. Comparatively few jobs in industry will involve research in pure physics and students who contemplate staying at the university for a Ph.D. ought to appreciate that the degree will not usually improve their prospects of advancement in industry.

5. Some university teachers consider that industry's lack of enthusiasm for the Ph.D. arises from the fact that, in physics, fundamental research, for which the Ph.D. is essentially a training, is very largely carried out in universities. It would help towards a resolution of the apparently conflicting demands of industry and the universities if more members of university staffs were aware of the problems of industry and the requirements of industrial research and more industrialists appreciated the crucial place of research and the research student in the modern university.

6. An extension of knowledge, beyond that appropriate to the present first degree courses, should form part of university training at postgraduate level. This should not be narrowly centred on an immediate field of research but should provide a substantial strengthening of the student's background knowledge of that part of physics in which his research is to be done. In some branches of physics this training will be of a mathematical nature. The average postgraduate student is not capable of achieving this extension in his own time and on his own initiative, and postgraduate teaching of a formal character is desirable for at least the great majority of research students. For these students there is a strong case for the concentration of this teaching into the first postgraduate year.

7. Many graduates who enter industry without taking a Ph.D. would benefit greatly from courses of advanced lectures similar to those which the research students ought to take. To organize these courses so that they could be available to both groups of students would meet a real industrial need, might ease the problem of organization within the universities and might help in the assessment of students capable of staying on for research. Further, courses of this kind might stimulate vitality and generally strengthen some university departments.

8. The universities are faced with serious problems of staffing and the development of postgraduate courses would aggravate these. This is a matter to which the University Grants Committee would need to give sympathetic consideration.

9. The great majority of university students—undergraduate and postgraduate—are dependent on maintenance grants. No improvement of training along the lines we suggest, involving for the best students at least an additional year at the university, is feasible unless the grant-awarding bodies, particularly the Department of Scientific and Industrial Research, are prepared to provide the necessary financial support.

10. Our report is only a first step in investigating a very big problem. We have concentrated almost exclusively on problems arising in the training of those working for the Ph.D. degree but we recognize that there are at least equally important problems involved in the further training of those who will take up professional work in physics immediately after taking a first degree. An attempt to investigate such a subject would involve consideration of the nature and extent of industry's need of scientific manpower."

Any Member of the Institute may obtain a copy of the report on request, free of charge ; copies are available to non-members at 2s. each inclusive of postage.

THE INSTITUTE OF PHYSICS

CONSOLIDATED INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1959

1958 £		£
18,731	To Production and distribution of publications (excluding cost of labour and overheads)	19,397
21,567	„ Salaries and National Insurance and staff superannuation	23,095
5,256	„ Rent, rates, lighting, heating, cleaning and maintenance	9,356
1,360	„ Board and Committee meetings expenses and travelling expenses	1,472
2,838	„ Printing and stationery	3,028
1,819	„ Bulletin (net)	2,108
2,919	„ Postages and telephone	3,182
2,826	„ Branches and Groups (including Australia)	2,931
291	„ Conference and Conventions (net)	400
487	„ Educational work, examinations and special reports (net)	1,008
859	„ Miscellaneous expenses	1,635
300	„ *Science Abstract* basic payment	300
59,253		67,912
	Less	
63	„ Increase in stock of publications	82
		67,830
—	Surplus before depreciation, etc.	2,929
£59,190		£70,759
28	To Balance brought down	—
378	„ Amount written off expenditure on alterations, etc., to House	378
337	„ Depreciation of furniture, fittings and office machinery	910
985	„ Leasehold Redemption Policy	985
—	„ Surplus for the year	656
£1,728		£2,929

1958 £		£
33,532	By Receipts from publications	39,632
7,828	„ Receipts from advertisements in Journals	7,762
15,898	„ Members' subscriptions, entrance and application fees	21,180
1,326	„ Dividends and interest	1,323
—	„ Donations received by Trust Fund	147
319	„ Non-Members' Conference fees	715
259	„ Income Tax recovered	—
28	„ Deficit for the year before depreciation	—
£59,190		£70,759
—	By Balance brought down	2,929
1,728	„ Deficit for the year 1958	—
£1,728		£2,929

THE INSTITUTE OF PHYSICS

CONSOLIDATED BALANCE SHEET, 31st DECEMBER, 1959

1958 £		£
4,722	LIFE MEMBERSHIP FUND	4,659
23,364	RESERVE FUND	23,937
	CURRENT LIABILITIES:—	
13,320	Subscriptions to 1960 Journals and payments from members in advance	13,580
5,679	For expenses including production of publications ...	7,569
22,795	A.S.T.M. File Fund	26,125
£69,880		£75,870

1958 £		£	£
	FIXED ASSETS:—		
	FURNITURE, FITTINGS AND OFFICE EQUIPMENT, at cost	10,141	
1,013	*Less* Depreciation	7,174	2,967
	ALTERATIONS, IMPROVEMENTS AND ADAPTATION OF PREMISES, at cost	10,289	
5,381	*Less* Depreciation	5,286	5,003
	CURRENT ASSETS:—		
2,670	STOCK ON HAND, at valuation		2,805
6,060	DEBTORS AND AMOUNTS PAID IN ADVANCE		7,772
31,089	INVESTMENTS, at cost		36,089
	(Estimated market value at 31st December, 1959, £35,594)		
8,865	LEASEHOLD REDEMPTION POLICY		9,850
12,239	BANK BALANCES AND CASH IN HAND		9,451
2,563	ENDOWMENT TRUST FUND		1,933
£69,880			£75,870

News of Members

FELLOWS

J. N. Aldington is now Group Managing Director of Associated Electrical Industries (Woolwich) Ltd., London.

A. Ashmore has been appointed Reader in Experimental Physics at Queen Mary College, London.

E. A. Calnan is Director of Research of Gillette Industries Ltd., Reading.

D. W. Davison is on the Central Personnel Executive Staff of The Plessey Co. Ltd., Ilford.

A. T. Green who recently retired from the Directorship of The Ceramic Research Association has had the honorary freedom of the City of Stoke-on-Trent conferred on him.

Ezer Griffiths has been elected Honorary President of the Institut International du Froid.

K. C. Lang has now returned to the Defence Standard Laboratories, Ascot Vale, Victoria, Australia.

J. Mazur has been appointed Professor of Experimental Physics at the University of Warsaw, Poland.

D. McGill is now Science H.M.I. on the General Staff of the Scottish Education Department.

P. W. Mummery is now Head of Industrial Power Reactor Division, The Atomic Energy Establishment, Winfrith, Dorset.

A. Nightingale has joined the Physics Staff of St. Thomas' Hospital, London.

R. Parker has been appointed Head of the Department of Mathematics and Physics in the College of Technology, Portsmouth.

Professor M. W. Thring has been elected Vice-President of The Institute of Fuel.

C. N. Watson-Munro has been appointed a Professor of Physics in the University of Sydney, New South Wales, Australia.

R. L. Whitmore is on the staff of the Department of Mining and Fuels of the University of Nottingham.

ASSOCIATES

L. Alpin has been appointed Technical Manager of Portland Plastics Ltd., Hythe, and Unitubes Ltd., Slough.

D. R. Ashworth is Assistant Chief Research Metallurgist with Hawker-Siddeley Nuclear Power Co. Ltd., Slough.

G. S. Barlow is an Assistant Lecturer in Physics at Blackburn Municipal Technical College.

K. Barron is in the Fuels Division of the Department of Mines and Technical Surveys at Ottawa, Canada.

I. J. W. Bissett is the Scientific Liaison Officer, Australian Atomic Energy Commission, at the Australian Embassy, Washington, U.S.A.

N. F. Blackburne is a Research Physicist with Shell Research Ltd., Thornton Research Centre, Cheshire.

I. D. Brotherton is in the Electronics Department of Rank Precision Industries Ltd., Hammersmith, London.

R. E. Burnett has been appointed Managing Director of Marconi Instruments Ltd., St. Albans.

D. J. Cairns is Lecturer in Physics at Enfield Technical College.

J. C. Castle has joined the Westinghouse Electric Corporation at Pittsburgh, U.S.A.

J. A. Champion is a Senior Scientific Officer at the Post Office Research Station, London.

P. J. Coppen is now a Senior Engineer with Texas Instrument Incorporated, Texas, U.S.A.

F. W. Crawford is a Research Associate at Stanford University, California, U.S.A.

B. P. Dash is Geophysicist in Hanover, Germany.

A. M. Dobson is now Production Manager at Fibreglass Ltd., St. Helens.

C. C. Doram has become a Lecturer in Physics at Birkenhead Technical College.

H. L. Evans has returned to Australia after two years at Imperial College, London.

V. Fidleris is a Senior Scientific Officer at the United Kingdom Atomic Energy Authority, Dounreay Experimental Reactor Establishment.

W. W. Foster is Food Process and Development Manager of Birds Eye Foods Ltd., Great Yarmouth.

B. A. Goddard has been appointed Senior Hospital Physicist at Dudley Road Hospital, Birmingham.

R. D. Hart is Joint Managing Director of Moler Products Ltd., Colchester.

J. Harwood is a Lecturer at Southall Technical College.

A. J. Kent is a Statistician with Mars Ltd., Slough.

R. G. Martin has been appointed Assistant Master at Wirral Grammar School, Bebington.

J. I. Mitchell is a Lecturer in Mathematics at the North Gloucestershire Technical College, Cheltenham.

D. Murray is on the staff of the National Engineering Laboratory, East Kilbride.

Thong Saw Pak is Professor of Physics in the University of Malaya, Kuala Lumpur.

D. G. Rieck has been appointed a Professor at the Technological University of Eindhoven, Holland.

J. M. Ritchie is now on the staff of the Department of Pharmacology at the Albert Einstein College of Medicine, Yeshiva University, New York, U.S.A.

A. A. Runki is Technical Manager of a subsidiary company of Edwards High Vacuum Ltd., in Frankfurt, West Germany.

J. E. Samson has become General Manager of Samor Pure Foods Ltd., Didcot.

A. B. Sarkar is now Engineer-in-Charge of Research and Development with Electronics Ltd., New Delhi, India.

M. C. Saxena has been appointed an Assistant Professor in the University of Lucknow, India.

K. W. Scott is a Safety Officer with Atomic Power Construction Ltd.

C. E. Skinner has been appointed Principal of Arnold and Carlton College of Further Education.

G. H. R. Smith has been appointed Assistant Director (Electronics Research and Development) in The Ministry of Aviation, London.

N. Sullivan is now Engineering Superintendent, Automatic Controls, Sperry Gyroscope Co. Ltd.

K. Sykes is a Senior Experimental Officer at the Royal Radar Establishment, Great Malvern.

B. J. Thompson has been appointed an Assistant Lecturer in the Department of Physics, The University of Leeds.

R. Thorburn has been appointed Senior Lecturer in Physics at South-West Essex Technical College, Walthamstow.

R. Ueda has now returned to Japan to the Department of Applied Physics of Waseda University, Shinjuku-Ku, Tokyo.

G. H. Vulkan has been appointed a Senior Scientific Officer in the Scientific Branch of the London County Council.

B. A. Worswick is now Technical Director, Elcontrol Ltd., Hitchin.

GRADUATES

F. Ashton is an Assistant Lecturer in Physics in the University of Leeds.

T. S. Billinge is a Production Engineer with the Metal Box Co. Ltd., London.

N. W. Bridge has been appointed Lecturer in the Mid-Cheshire College of Further Education, Hartford.

K. H. D. Cowen is a Research Engineer with the Westinghouse Brake and Signal Co. Ltd., London.

R. J. Day is Assistant Production Manager with Triangle Valve Co. Ltd., Wigan.

Miss D. Dick is an Engineer Mathematician with the South of Scotland Electricity Board, Cathcart, Glasgow.

F. J. Fayers is Senior Physicist with the English Electric Co. Ltd., Atomic Power Division, Leicester.

J. D. Forrester is an Assistant Lecturer in the Technical College, Brighton.

H. G. Frost has been appointed Staff Lecturer in the Extra-Mural Department of the University of London.

L. S. Gay is a Lecturer in Physics in the University of Natal, Durban, South Africa.

M. J. Harris has been appointed as Assistant Lecturer in the Department of Engineering, The University of Manchester.

Dr. K. C. Holmes is visiting the Children's Cancer Research Foundation, Boston, Massachusetts, U.S.A.

D. C. Laine is a Senior Physicist with Glass Developments Ltd., London.

V. J. Long has been appointed Development Engineer with Standard Telephones and Cables Ltd., Paignton.

E. H. Noe is a Technologist in the Nucleonics Department of the British Scientific Instrument Research Association, Chislehurst.

R. W. Palmer is on the staff of the English Electric Co. Ltd., Chelmsford.

K. R. Parker has been appointed Deputy Head of the Research and Development Department of Lodge-Cottrell Ltd., Birmingham.

D. G. Perry is Assistant Experimental Officer at the Atomic Weapons Research Establishment, Aldermaston.

T. C. Sinclair is now with the Reactor Physics Section, Nuclear Health and Safety Branch, Central Electricity Generating Board, London.

D. T. Strike has been appointed an Assistant Lecturer in Physics at Farnborough Technical College.

J. Swiatkiewicz is a Senior Development Engineer at Elgar Research Laboratory, Mytchett, Nr. Aldershot.

E. Taylor is Assistant Physics Master at The Royal Grammar School, Lancaster.

G. M. Thomas is an Assistant in the Department of Natural Philosophy, The University of Edinburgh.

Reviews of Books

THE SPECIAL THEORY OF RELATIVITY

By J. Aharoni

London : Clarendon Press : Oxford University Press. Pp. viii + 285. Price 45s.

That there was room for another book on the special theory of relativity is amply demonstrated by this volume, which departs from most other books on the subject both in the relative weight given to different parts of the field and in the presentation of the mathematical background. Thus it relegates optical effects to a brief appendix and instead concentrates on the dynamics of particles, fluids and fields ; and it introduces tensors and spinors through group theory and not through linear transformations. In both these ways the book is in line with modern thought. Wisely too, the author has eschewed long and semi-philosophical discussions of the conceptual difficulties of the theory. It is now over fifty years since the *annus mirabilis* 1905, and the passage of time has worked the usual transformation by which we now find it difficult to understand the difficulties that even the greatest of scientists found in understanding the theory when it was new. Instead the reader's mind is firmly directed towards the difficulties of to-day and tomorrow—an understanding of quantum theory and of the theory of elementary particles.

The book will be most useful to mathematicians and mathematical physicists in their final undergraduate and postgraduate years, but there is much there too that will be of use and interest to the type of experimentalist who wants to know what the theoreticians are doing. For most of the time the treatment is brilliantly clear and enlivened by plentiful references to physical situations, so that the reader should find no undue difficulties, provided he does not start skipping, for this is a book to be worked through. The last chapter, on spinors, is, however, in a different category, since here only the most minute attention to detail will see the reader safely through to the end, and even then he may have lost the main thread of the argument in the process. Since the avowed purpose of the book is to prepare for relativistic quantum mechanics, it is essential to get to the end of it with a full understanding of what is going on. For this to be possible I feel that the last chapter should be substantially re-written in a future edition.

While, with the exception of the last chapter, the general treatment could hardly be bettered, I am a little unhappy about some of the statements made which have no direct bearing on the development of the main argument. Thus the author says that " Lavoisier's law of the conservation of matter, for which there exists no theoretical foundation, rested solely on chemical observation." All physical laws rest solely on observation and our belief for the equivalence of matter and energy rests on the experimental observations of nuclear physics and not on the generalization to four-vectors of Newton's laws of motion. Equally misleading is the assertion in the appendix that the quantum theoretical description of the wave-particle duality of light somehow explains the apparently corpuscular properties of light, such as its ability to travel through a vacuum, which led Newton to his corpuscular theory. There are no points of contact between Newton's and Planck's corpuscles.

These are small faults in an excellent book that ought to be on the shelf of all young physicists worth their salt. And for those that love the mischievous activities of the printer's devil I recommend p. 276 where it is stated that " in the case of electromagnetic waves in free space there is now dispersion."

L. R. B. Elton.

PHYSICS AND ELECTRONICS IN PHYSICAL MEDICINE

By A. Nightingale

London : G. Bell & Sons, Ltd. Pp. 292+x. Price 30s.

> " God only knows what the ingenious heads of our time will get out of it all . . . If it must have some practical use, it is certain that none has been found for it in Theology or Jurisprudence, and therefore where else can the use be than in Medicine ? "

These were the views of Johann Gottlob Krüger, professor of philosophy and medicine at Halle, when he lectured to his students in 1743 on the possible usefulness of electricity. He went on to offer some practical suggestions which led to the foundation of physical medicine, a group of techniques still widely useful in the study and treatment of many conditions affecting the muscles or peripheral nerves. The seniority of this branch of the healing art is evidenced by the names and methods that it uses. The passage of direct current through the tissues is known as *galvanism* and the pulsed d.c. used for stimulating sluggish muscles is called the *faradic current.* Radio frequency currents, used for internal heating, are often produced by spark-gap generators.

Dr. Nightingale is one of a small group of people who have made important contributions to physical medicine by applying modern ideas to its analysis and development. This book is intended for the instruction of doctors and physiotherapists studying for specialized examinations and contains much that will be of interest to anyone concerned with the applications of physics in medicine.

The first half is devoted to a straightforward account of the scientific foundations—mechanics, fluid flow, heat, electricity and wave motion—with many apt illustrations drawn from medical practice. Some of them are unexpectedly ingenious. Describing how to find the centre of gravity of an irregular object by hanging it from successive corners the author explains that such a method cannot be used on the living human body " although," he adds darkly, " it has been applied to frozen cadavers."

The second part of the book deals with the applications of direct, alternating and radio-frequency currents and of ultra-violet radiation in medicine. These chapters contain lucid surveys of the broader issues with careful explanations on detailed points and numerous excellent illustrations—all the characteristics, in fact, of the well-known textbooks written by Dr. Nightingale's father. The family tradition is in good hands.

J. M. A. LENIHAN.

MEASUREMENT : DEFINITIONS AND THEORIES

Edited by C. West Churchman and Philburn Ratoosh

London : Chapman and Hall Ltd. Pp. viii + 274. Price 64s.

Although the contents of this book are, potentially, of very great interest to all scientists—and particularly to all physicists since physics has been defined as the science of measurement—it must regretfully be pointed out that much of its value is lost because the book is virtually unreadable. This is not so much because the authors of the various chapters are mainly psychologists or philosophers as because the material is presented in very much the same form as that in which it was originally delivered at a symposium for specialists. No concessions whatever are made to the general reader—this is not a textbook or even a series of connected discourses, but simply a series of statements of individual points of view or conclusions on the subject of measurement in many of its aspects. Technical jargon of a most formidable kind is used from the outset, e.g. " Given that monotonicity is satisfied with laterality held constant there may exist a valid transformation of measures of inconsistency into measures of psychological distance ", and as the basic ideas involved are necessarily somewhat abstruse any attempt to do much more than browse through the book involves prolonged study.

But this should be read as a warning rather than as a criticism, for the searching analysis of ideas which many of us habitually accept without further thought can be very salutary, and even on a casual glance through this book one comes across statements that provoke a re-examination of one's ideas. The subjects discussed are the meaning of measurement (" What is it that measuring accomplishes that non-measuring does not ?"), theories of measurement, some problems of measurement in the physical sciences (quantum concepts and the measurement of rare events), and some problems in the social sciences (the measurement of preferences and of inconsistencies of choice).

Clearly, no summary of such a book is possible, but two of the ideas described may convey some idea of the range of topics discussed. The first concerns the measurement of subjective values. The procedure used was to say to a subject " I am going to give you £10. That will make you happy, will it not ? Now, how much should I have to give you to make you twice (or half) as happy ? " The second idea is concerned with the exploration of the supernatural. The author criticises previous demonstrations in that they have not led to the establishment of new facts that could be checked by living persons. He suggests that the following experiment would be decisive: Fermat claimed to have found a simple proof for his famous theorem that the equation $x^n+y^n=z^n$ has no solution in positive integers x, y, z for any value of n greater than two. Although the theorem seems to be true, nobody has yet been able to give a complete proof. Let us ask Mr. Fermat to dictate his proof to a turning table !

A. E. DE BARR.

PHYSICAL METHODS OF INVESTIGATING TEXTILES

Edited by R. Meredith and J. W. S. Hearle

London : Interscience Publishers Ltd. Pp. ix + 411. Price 88s.

This is not so much a bad book as a futile book—using that adjective in all its connotations. Like so many similarly heterogeneous collections of essays published at the present time, this book began as a series of lectures and, following the all-too-familiar pattern that threatens to overload the shelves (and the budgets) of libraries, these have now been published in book form. The blame for turning all these probably admirable lectures into largely unnecessary books seems to me to be shared between the publishers, the organizers-cum-editors, and the librarians of institutional libraries. These latter, anxious to maintain full coverage of their organization's field of activity, tend too readily to buy any book with an appropriate title—almost regardless of the actual content of the book. Publishers, realizing this, know that they can rely on selling at least the necessary minimum number of copies of almost any book with a suitably chosen title, and seek readily-tapped sources. To complete the chain, organizers of lecture series, not always careful enough of their reputations, succumb too easily to the temptation of having a book to their name, even if only as editors. In this connection it is interesting to note that the editors of this book, in their preface, give as the reason for publishing the lectures in book form, not that they might form a useful book but that it was "suggested that they (the lectures) deserved a more lasting presentation." They do not tell us whose suggestion this was !

There is so much to criticize in this book that it is hard to know where to begin. But particular mention must be made of the illustrations, many of which, although well-reproduced, are quite valueless. A large proportion of the plates reproduce photographs of apparatus of the type that used to appear in some scientific papers but which, fortunately, are now rare since it has long been realized that the amount of information they convey is quite negligible. Fig. 7.9—" A microprojector set up for fibre migration studies " is a good (or should it be bad), although by no means the only, example. The photograph shows a commercial instrument with some unidentifiable equipment on the stage and nothing visible on the screen. Unfortunately, many of the line diagrams can be similarly criticized : a lot of space in them is taken up with G-clamps, bell-jars, bourdon gauges, spring clips, etc.

The text itself is unsatisfactory partly because it is almost completely uncritical (in places it becomes little more than a catalogue of references), but mainly because of the heterogeneous nature of the subject material. Inevitably much of the space is taken up with relatively elementary accounts of, for example, radioactivity, microscopy, infra-red spectroscopy, etc.—material that has been published many times already (and has appeared before in other books of this kind !) and that anyone who could be expected to be interested in this book could well find more expertly treated elsewhere. Even granting the need for introductory accounts of this kind in the original lectures, I am puzzled to know what the non-specialist is expected to make of, for example, the discussion of electron lenses on pp. 90-93 or that of X-ray crystallography in the first chapter. The chapter on applications of nuclear physics consists almost entirely of simple textbook material but the more specifically textile chapters—those on yarn and fabric structure and properties—are rather better in this respect. Even these, however, are reasonably intelligible only to the specialist, for whom the treatment is too compressed and uncritical to be of any value.

I think that this was probably a most useful and interesting series of lectures but I cannot believe that anyone will find the book either interesting or useful.

A. E. De Barr.

FLUID MECHANICS

By L. D. Landau and E. M. Lifshitz
Translated from the Russian by J. B. Sykes and W. H. Read

London : Pergamon Press Ltd. Pp. xii + 536. Price 105s.

It is fascinating to see between one pair of covers the development of fluid mechanics through Russian eyes, especially when the translation is as good as this one. In the event the book is one which will have to find its way on to the shelves of all those seriously interested in the subject. In coverage and treatment it comes under the heading of a text for advanced students ; it is not, it must be emphasized, an easy book to read, the pace is too spanking for that and so many important results find themselves classed as examples. Any student who really delves into it however will find it very rewarding.

The reward for the established worker comes as much from seeing familiar things from different angles as from seeing, to quote from the preface, " some topics not usually found in textbooks on the subject . . . the theory of combustion ; the dynamics of superfluids : and relativistic fluid dynamics." (I have I confess omitted from this list the theory of heat transfer and diffusion and acoustics which the authors included in it but which do in my experience often find their way into such texts.)

Even so I didn't find all the approaches that were new to me impeccable. For instance the treatment of separation in a laminar boundary layer gives a derivation in a few lines of the result that the skin friction near the point of separation behaves like the square root of the distance from that point. This is a result which I think it would be fair to say has only been established on this side of the iron curtain with much toil and sweat if not tears. The derivation under review is however based on the assumption that one of the expansions employed is regular—an assumption which almost begs the question.

It would be idle to pretend that the references are as complete as one would have liked to see and this is perhaps my most serious criticism of the book. There is for instance no mention of the work to which I have just referred in the section on separation whilst on the other hand very many results find their way into the text and examples without any reference whatever to the original investigation. All other considerations on one side this makes it very difficult for the uninitiated to pursue a subject beyond the confines of the book.

At five guineas the price compares unfavourably with competitive British works but must be much the same as a comparable American work.

L. Howarth.

THE HUMAN ELEMENT IN RESEARCH MANAGEMENT

By B. E. Noltingk

London : D. Van Nostrand Company Ltd. Pp. vi + 91. Price 9s. 6d.

Though written primarily for those responsible for the management of research organizations, Mr. Noltingk's book could be read with benefit by every scientist and layman interested in such an organization. Success in research, in his opinion, depends first and foremost on the proper handling of personnel. This theme he develops to show that the interests of the individual are one with the interests of the organization, and there is no place for the square peg in the round hole.

He deals with the qualities required in a research worker, discusses problems of recruitment, salaries, promotions and dismissals and considers the problem of the ageing scientist in research. There is an interesting discussion on the organization of a laboratory : the lay-out of the building, the costing of research projects and the part to be played by the ancillary services of workshop, drawing-office, stores, library and administration. The interrelation of senior and junior staff and the essential qualities of a director of research and his proper function in the organization are admirably portrayed. The strategy and tactics of research are reviewed. He emphasizes the importance of recognizing the interaction of fundamental research and industrial development, of selecting the right projects, assessing their value and knowing when work should be terminated. A laboratory cannot prosper without advertisement, and Mr. Noltingk deals fully with the many ways in which advertisement can be achieved. " High output," he says, " is necessary, however indefinable it may be, for without it external prestige falls and internal morale vanishes." His final chapter on ethics underlines what has been implicit in the rest of his book, but the qualities of honesty, humility, loyalty, justice and good temper, which he considers, are not requirements peculiar to the staff of research organizations. The suggestion that the achievement of a high standard in these qualities depends on a particular religious faith, although put forward as a personal conviction, seems out of place.

In conclusion, this is a book that will stimulate thought and should prove of value to anyone with a stake in the success of a research organization.

S. Fitzmaurice-Kelly.

Forthcoming Institute Meetings

Date	*Place*	*Speaker*	*Title*	*Time*	*Branch or Group*
April 21	**Middlesborough** Cleveland Scientific and Technical Institute	Mr. H. A. Prime, A.M.I.E.E. (*Brush Electrical Engineering Co. Ltd.*)	**The Jodrell Bank telescope**	6.30 p.m.	North-Eastern jointly with the Society of Instrument Technology
April 21	**Birmingham** The University		Group Annual General Meeting	5.00 p.m.	Education
April 21 April 22	**Birmingham** The University College of Technology	Principal speakers to be announced	Joint Symposium on **The training of the industrial physicist**		Education jointly with Midland
Registration is necessary. Full details may be obtained from the Secretary of the Institute.					
April 22	**Birmingham** University Union		Branch Annual Dinner	7.00 p.m. for 7.30 p.m.	Midland
Further details will be sent to Midland Branch members.					
April 29	**Aberystwyth** University College of Wales	Dr. R. Morgan (*Hammersmith Hospital, London*)	**Some aspects of ionizing radiation in medicine**	5.15 p.m.	South Wales
April	Full details will be sent to members of the Electron Microscopy Group		Conference on **Correlation of optical and electron microscopy**		Electron Microscopy jointly with Royal Microscopical Society
May 2 to 4	**London** Institution of Mechanical Engineers		Joint Conference with Société Française de Métallurgie. The general theme will be on the relationship between structure and physical properties of materials and will include recent advances in non-destructive testing techniques.		Non-Destructive **Testing**
Registration is necessary. Full details may be obtained from the Secretary of the Institute.					
May 3	**London** Park Lane Hotel		**Institute Annual Dinner**	7.00 p.m. for 7.30 p.m.	
Further details will be sent to all members.					
May 12	**Liverpool** The University	Dr. J. W. Glen (*University of Birmingham*)	Branch Annual General Meeting followed by a lecture on **The physics of glaciers**	7.00 p.m.	Liverpool and North Wales

The Register

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Lee, Brian, B.Sc.Tech., Physics Master, St. Gregory's Technical High School for Boys, Manchester.

*Lewis, David John Garth, B.Sc., Electronic Engineer, The Fairey Aviation Co. Ltd., Surrey.

Lickard, Albert Ernest, B.Sc., Physicist, Rowntree & Co. Ltd., Cocoa Works, Yorks.

Lim, Guan Seang, B.Sc., Physics Master, King George V School, Malaya.

Lloyd, Gordon John, B.Sc., Circuit Engineer, Standard Telephone & Cables Ltd., Newport, Mon.

*Lumb, Michael David, B.Sc.Tech., Research Student, The Manchester College of Science and Technology.

McDougall, William Gordon, B.Sc., Technical Scientific Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

Martin, Michael David, B.A., Valve Development Engineer, Standard Telephone & Cables Ltd., Paignton, Devon.

*Michell, Peter Ralph, B.Sc., Assistant Instrument Manager, Imperial Chemical Industries Ltd., Castner Kellner Works, Runcorn, Cheshire.

Mills, Alan Frederick, B.Sc., Technical Officer, Imperial Chemical Industries Ltd., Welwyn Garden City, Herts.

*Moss, David John, B.Sc., Postgraduate Student, University of Birmingham.

*Palmer, Barry Montague, B.Sc., Physicist, Tate & Lyle Ltd., Keston, Kent.

Parkhouse, Peter George John Thomas, B.Sc., Research Student, University of Durham.

Paxton, William Grahame, B.Sc., Engineer, S. Smith & Sons (England) Ltd., Cheltenham, Glos.

Pearse, Heather Ann, B.Sc., Research Physicist, Bristol Cellophane Ltd., Bridgwater, Somerset.

*Pennells, Peter Jack, Dip.Tech., Textile Physicist, Dunlop Rubber Co. Ltd., Erdington, Birmingham.

Perry, Geoffrey Edward, B.Sc., Senior Physics Master, Kettering Grammar School.

*Pritchard, Peter Charles, Dip.Tech., Graduate Physicist, Dunlop Rubber Co. Ltd., Erdington, Birmingham.

Ray, Brian, B.Sc., Research Scientist, Associated Electrical Industries, Research Laboratories, Harlow, Essex.

Read, Anthony George, B.A., Acting Shop Manager, U.K. Atomic Energy Authority, Capenhurst, Chester.

Reece, Barrie Lloyd, B.Sc., Research Student, University of Birmingham.

Robinson, Brian, B.Sc., Research Student, The Manchester College of Science and Technology.

*Rooke, Gilbert Arnold, Research Student, University of Western Australia.

*Shaw, Kenneth James, Scientific Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

*Sherborne, Beryl Margaret, B.Sc., Assistant Teacher, Forest Fields Grammar School, Nottingham.

Skinner, David Robert, B.Sc., Technical Assistant, Short Bros. and Harland Ltd., Castlereagh, Belfast.

*Smith, Kenneth, B.Sc.Tech., Development Engineer, Ferranti Ltd., Manchester.

*Snape, Geoffrey Proctor, B.Sc.Tech., Scientific Officer, U.K. Atomic Energy Authority, Windscale Works, Sellafield, Cumberland.

Stitson, James Arthur Robert, B.Sc., Apprentice, The Mullard Radio Valve Co. Ltd., Surrey.

Stocks, Trevor, B.Sc., Shop Manager, The Health and Safety Department, U.K. Atomic Energy Authority, Springfields Works, Preston, Lancs.

Surtees, Thomas Richardson, B.Sc., Research Physicist, The General Electric Co. Ltd., Research Laboratories, Wembley, Middlesex.

Swain, John Robert, Dip.Tech., Experimental Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

*Symons, Charles Richard, B.Sc., Scientific Officer, Atomic Energy Establishment, Winfrith, Dorchester, Dorset.

Szaz, Kalman Ferenc, B.Sc., Physicist, Eastern Regional Hospital Board, Dundee.

Taylor, John Michael, Engineer, English Electric Aviation Co. Ltd., Luton, Beds.

Thompson, Michael Geoffrey, B.Sc., Research Student, University of Leeds.

Tollin, Patrick, B.Sc., Research Student, Cavendish Laboratory, Cambridge.

Watson, Derek Michael, B.Sc., Senior Physics Master, Sir George Monoux Grammar School, Walthamstow, London.

*Watson, John Merza, Dip.Tech., Research Student, University of Manchester.

Wilson, Gordon Edwin, B.Sc., Assistant Experimental Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

Windsor, Gregory, B.A., Physicist, Mullard Research Laboratories, Salfords, Surrey.

Wright, Donald Curtis, B.Sc., Research Student, King's College, Newcastle-on-Tyne, Durham.

Wyatt, Peter Richard, B.Sc., Physicist, Mullard Research Laboratories, Salfords, Surrey.

Ninety-three Students and eight Subscribers were also admitted.

Report of the Board of The Institute of Physics for the year 1959

TO BE PRESENTED FOR ADOPTION AT THE ANNUAL GENERAL MEETING OF THE INSTITUTE ON JULY 5, 1960

The Board and its Committees

The present Board took office on October 1, 1959; its members on December 31, 1959, were:

President: Sir George Thomson.

Immediate Past Presidents: Mr. O. W. Humphreys, Sir John Cockcroft.

Vice-Presidents: Dr. B. P. Dudding, Dr. J. M. A. Lenihan, Dr. R. W. Sillars, Professor E. C. Stoner.

Honorary Treasurer: Dr. J. Taylor.

Honorary Secretary: Dr. F. A. Vick.

Ordinary Members of the Board: Dr. V. E. Cosslett, Dr. A. C. Menzies, Mr. F. Oldham, Mr. L. Rotherham, Dr. J. Thewlis, Dr. J. Topping, Dr. L. R. G. Treloar, Mr. G. W. Warren.

Chairmen of Branches in Great Britain: Mr. F. I. Hurley (Liverpool and North Wales), Professor A. M. Taylor (London and Home Counties), Professor H. Lipson (Manchester and District), Dr. J. H. Davis (Midland), Dr. O. P. T. Kantorowicz (North-Eastern), Dr. G. A. P. Wyllie (Scottish), Dr. M. R. Hopkins (South Wales), Professor S. H. Piper (South-Western), Dr. A. B. D. Cassie (Yorkshire).

Representing The Physical Society: Dr. D. A. Wright, Dr. C. G. Wynne.

During the year the Board met five times and appointed the undermentioned Standing and Executive Committees which held nineteen meetings.

Finance and General Purposes Committee (*Chairman:* The Treasurer).

Membership and Education Committee (*Chairman:* Dr. M. R. Hopkins).

Benevolent Fund Committee (*Chairman:* Dr. J. Taylor).

Journals Advisory Committee (*Chairman:* Dr. J. M. A. Lenihan).

Meetings Committee (*Chairman:* Dr. R. W. Sillars).

Non-periodical Publications Committee (*Chairman:* Dr. F. A. Vick).

Careers in Physics Committee (*Chairman:* Dr. J. M. A. Lenihan).

Physics of Nuclear Power Committee (*Chairman:* The President).

Organizing Committee for the Symposium on Current Developments in the Production of High Vacua (*Chairman:* Mr. J. Yarwood).

Organizing Committee for the Conference on Some Aspects of Magnetism (*Chairman:* Professor W. Sucksmith).

Representatives and nominees on Joint Committees and other bodies

The Institute has been represented as follows and summaries of the principal work of those bodies likely to be of interest to members are given in the appendix to this Report.

On The Royal Society's National Committee for Physics: Dr. F. A. Vick.

On The Royal Society's National Committee for Crystallography: Dr. W. H. Taylor.

On The Royal Society's Paul Instrument Fund Committee: Dr. F. A. Vick.

On the Board of The British Nuclear Energy Conference: The President, Dr. J. V. Dunworth and Dr. H. R. Lang.

On the Parliamentary and Scientific Committee: Dr. F. A. Vick and Dr. H. R. Lang on the General Committee, together with Mr. O. W. Humphreys and Dr. J. Taylor at the Annual Meeting.

On the Committee of Management of Science Abstracts: Dr. L. R. G. Treloar.

On the Joint British Committee for Vacuum Science and Technology: Dr. R. W. Sillars and Mr. J. Yarwood.

At the exploratory meeting of Societies interested in Electron Microscopy: Mr. A. W. Agar, Dr. J. W. Menter.

At the exploratory meeting of Societies interested in Stress Analysis: Mr. A. F. C. Brown, Dr. H. Fessler.

On the Organizing Committee of the International Congress of Crystallography: Professor E. G. Cox.

On the Planning Committee of the International Conference on the Teaching of Physics: Mr. N. Clarke.

On the British Committee for Radiological Units: Mr. W. Binks.

On the British National Committee for High Speed Photography: Dr. W. D. Chesterman.

On the British National Committee for Non-Destructive Testing: Dr. J. Thewlis.

On the British Group for Computation and Automatic Control of the British Conference on Automation and Computation: Dr. A. D. Booth and Mr. N. Clarke.

On the Joint Committee with the Ministry of Education for National Certificates in Applied Physics: Mr. A. E. De Barr, Mr. F. I. Hurley, Dr. J. Topping and Mr. G. W. Warren.

On the Joint Committee with the Northern Ireland Ministry of Education for National Certificates in Applied Physics: Dr. C. P. Black, Mr. J. A. Matthew, Dr. R. H. Sloane.

On the Joint Committee with the Scottish Education Department for National Certificates in Applied Physics: Mr. J. R. Atkinson, Dr. J. M. A. Lenihan and Dr. G. Morris.

On the Joint Committee (with The American Society for Testing Materials and The American Crystallographic Association) for Chemical Analysis by X-ray Diffraction Methods: Professor A. J. C. Wilson.

On the Ministry of Labour and National Service's Panel on Special Regulations for Protection against Ionizing Radiations: Mr. H. P. Rooksby, Mr. W. E. Schall.

On The Physical Society's Exhibition Committee: Mr. N. L. Harris.

On the National Council for Technological Awards' Board of Studies in Technologies other than Engineering : Dr. N. F. Astbury.

On the City and Guilds of London Institute's Advisory Committee on Courses for Laboratory Technicians : Mr. N. Clarke, Mr. T. H. Tyler and Mr. L. Walden.

On the City and Guilds of London Institute's Advisory Committee on the Training of Instrument Mechanics and Technicians : Mr. N. Clarke.

On the City and Guilds of London Institute's Advisory Committee on Industrial Radiography : Mr. N. Clarke, Mr. F. Y. Poynton and Mr. W. E. Schall.

On the Panel for Consideration of School Examination Syllabuses in Physics of the Science Masters' Association : Dr. L. R. B. Elton.

On the Court of the University of Exeter : Professor S. H. Piper.

On the Court of the University of Hull : Dr. E. C. Craven.

On the Court of Governors of Manchester College of Science and Technology : Dr. R. W. Sillars.

On the Governing Body of Brunel College of Technology : Mr. E. R. Davies.

On the Governing Body of Croydon Technical College : Mr. C. L. S. Gilford.

On the Governing Body of Kingston Technical College : Dr. G. D. Robinson.

On the Governing Body of Norwood Technical College : Dr. W. Betteridge.

On the Governing Body of Rutherford College of Technology : Mr. G. N. Peel.

On the Governing Body of South East London Technical College : Dr. J. Thomson.

On the Governing Body of the Welsh College of Advanced Technology, Cardiff : Dr. H. O. Puls.

On the London Regional Advisory Committee for Applied Physics : Mr. N. Clarke, Mr. F. Y. Poynton, Mr. G. W. Warren.

On the Technical Education Sub-Committee of Monmouthshire Education Committee : Dr. P. Hatfield.

On the Joint Science Advisory Sub-Committee of the Regional Council for Further Education in the South West : Professor S. H. Piper.

On the Advisory Sub-Committee for Electrical Engineering and Applied Physics of the Welsh College of Advanced Technology, Cardiff : Mr. R. G. Wood.

On the Sub-Committee on Specialist Courses in Electrical Engineering of the Welsh Academic Board of Technology : Mr. W. S. Vernon.

On the Advisory Committee for Electrical Engineering of Rutherford College of Technology : Mr. G. N. Peel and Dr. E. E. Schneider.

On the Consultative Committee for Physics of Norwood Technical College : Mr. N. Clarke.

On the Consultative Committee for Electrical Engineering and Applied Physics of the South East London Technical College : Mr. N. Clarke.

On the Advisory Panel in Physics of Brunel College of Technology : Dr. J. S. Forrest.

On the Advisory Committee on Physics of Battersea College of Technology : Dr. W. F. Berg.

On the Applied Science Advisory Committee of Birmingham College of Advanced Technology : Mr. M. Milbourn.

On the Science Advisory Committee of Ipswich School of Technology : Mr. H. A. Nancarrow.

On the Science Advisory Committee of Blackburn Municipal Technical College : Dr. A. Hargreaves.

On the Science Advisory Committee of Bournemouth Municipal College of Technology and Commerce : Mr. A. F. Blaylock.

On the Science Advisory Committee of Bury Municipal Technical College : vacancy

On the Science Advisory Committee of Croydon Technical College : vacancy.

On the Science Sub-Committee of the Eastern Area Technological Committee of the East Anglian Regional Advisory Council for Further Education : Mr. H. A. Nancarrow.

On the Science Advisory Committee of Ewell County Technical College : Dr. J. S. Forrest.

On the Council for Science of Ipswich Civic College : Mr. H. A. Nancarrow.

On the Advisory Panel for Applied Physics of West Midlands Advisory Council for Technical Commercial and Art Education : Dr. R. E. Bastick, Mr. M. Milbourn.

On the Advisory Committee for Applied Physics of Kingston Technical College : Dr. G. D. Robinson.

On the Science Advisory Committee of Luton and South Bedfordshire College of Further Education : Dr. R. W. Williams.

On the Science Advisory Committee of Merseyside District Advisory Council for Further Education : Professor J. D. Craggs.

On the Science Advisory Committee of Northampton College of Advanced Technology : Dr. J. T. Kendall.

On the Science Advisory Committee of Poole College for Further Education : Mr. C. F. Oxbrow.

On the Applied Science Advisory Committee of Bristol College of Technology : Dr. C. F. Shannan.

On the Applied Science Advisory Committee of the Royal Technical College, Salford : Mr. W. J. Meredith.

On the Science Advisory Committee of Salisbury and South Wilts College of Further Education : Mr. H. L. Green.

On the Science Advisory Committee of Slough College of Further Education : Mr. J. Yarwood.

On the Science Advisory Committee of Southend-on-Sea Municipal College : Mr. N. Clarke.

On the Advisory Committee for Physics of West Ham College of Technology : Mr. L. V. Chilton.

On the Applied Science Advisory Committee of the Wolverhampton and Staffordshire College of Technology : vacancy.

On the Yorkshire Council for Further Education Advisory Panel for Physics : Mr. S. L. Anderson, Dr. K. W. Andrews, Mr. D. F. Burnett, Dr. E. C. Craven, Dr. M. McCaig, Mr. B. O. Payne.

On British Standards Institution Committees : The Institute has been represented on twenty-two Committees of the B.S.I.

General Meetings

The 39th Annual General Meeting of the Institute was held on July 7 and an Extraordinary General Meeting (see below) on December 1, both in the Institute's House.

Membership

During the year 933 applications for election or transfer to the various grades were received for submission to the Membership and Education Committee, compared with 851 applications in 1958. The numbers for the grades (with the 1958 numbers in brackets) were:

Fellows ...	75 (74)
Associates ...	296 (227)
Graduates ...	276 (224)
Subscribers ...	16 (18)
Students ...	280 (308)

The Interview Panel met three times and interviewed twenty-one candidates.

In October Dr. M. R. Hopkins became chairman of the Committee in succession to Mr. G. W. Warren whose period of service expired. Professor S. H. Piper and Mr. G. W. Warren retired as members of the Interview Panel ; Professor J. G. Wilson and Dr. A. J. Maddock have been appointed to the Panel.

Representatives of the Committee visited five further technical colleges which had applied for recognition by the Institute as institutions having courses of study approved for the purpose of the membership regulations. All five were accepted.

The continued growth of the Institute is shown in the following table.

Table 1. *Growth of the Institute over the last ten years*

1950 ...	3858	1955 ...	5146
1951 ...	4080	1956 ...	5531
1952 ...	4347	1957 ...	5894
1953 ...	4749	1958 ...	6309
1954 ...	4995	1959 ...	6756

The changes that have occurred during the year are displayed in Table 2.

Deaths. The Board records with regret the deaths in 1959 of :

Honorary Fellows : Sir Owen Richardson, C. T. R. Wilson. *Fellows :* W. R. G. Atkins, J. Bannon, J. A. Darbyshire, Sir Alfred Egerton, C. E. Foster, W. Rheinallt Thomas, Sir Henry Tizard, F. Twyman, M. D. Waller. *Associate :* C. F. Hill. *Subscribers :* A. Mellick, H. Morton, L. van Ouwerkerk, R. J. Wilkins.

Examinations

Graduateship Examination. The number of candidates entering for the Graduateship examination continues to increase at a very satisfactory rate. One hundred and nineteen candidates, including seven taking only part of the examination, took papers other than the general paper, compared with a total of 80 candidates in 1958 and 68 in 1957. 39 candidates were successful and of these 13 held university degrees and 26 the Higher National Certificate in Applied Physics. Since the examination was established in 1952, 466 candidates have taken it and 136 have been successful ; of the successful candidates 55 hold university degrees, 74 the Higher National Certificate in Applied Physics while 7 hold neither of these qualifications.

Fifteen question papers were set and the examiners were Professor J. G. Craggs, Professor H. Lipson, Mr. A. E. De Barr, Dr. C. A. Taylor, Dr. A. W. Gillies, Mr. E. D. Van Rest, Mr. W. H. Reece, Dr. D. Green, Mr. N. Clarke and Mr. J. Yarwood. Professor Lipson has now retired as an examiner and Mr. J. R. Atkinson has been appointed in his place.

The examination papers set in the 1959 examination and the comments of the examiners were published in the September *Bulletin* and subsequently as a pamphlet.

For some time the Graduateship examiners have felt that changes ought to be made in the regulations of the examination in the light of experience. As a result proposals involving a new structure for the examination, which would be in two parts, were made to the Membership and Education Committee and accepted by the Committee and subsequently by the Board. The new regulations and syllabuses will operate from 1962.

National Certificates in Applied Physics. Forty-six technical colleges presented 820 candidates for the Ordinary National Certificate in Applied Physics and 23 colleges presented 296 candidates for the Higher National Certificate. The respective numbers of candidates in 1958 were 637 and 246 and in 1957, 542 and 182. The Institute's assessors were Professor J. Craggs, Mr. A. E. De Barr and Dr. J. Crank for England and Wales and Dr. J. M. Valentine for Scotland. Details of the results at individual colleges were published in the November *Bulletin.*

At the request of the Northern Ireland Ministry of Education a Joint Committee with the Institute was set up to administer schemes for National Certificates in Applied Physics in the Province.

An important development during the year was the acceptance of proposals to introduce rules under which new courses biased strongly towards instrumentation could be approved and would lead to a Higher National Certificate in Applied Physics (Instrumentation). Discussion of the best provision of part-time education for instrument technicians has been going on for some years and the new arrangements are the result of recommendations of a small working-party of Her Majesty's

Table 2. *Changes in the Register in 1959*

	Total on Dec. 31, 1958	*Elections*		*Re-admitted*	*Resigned*	*Deceased*	*Removed*	*Transfers from*	*Net Increase or Decrease*	*Total on Dec. 31, 1959*
		New	*Transfers to*							
Hon. Fellows ...	8	—	—	—	—	2	—	—	− 2	6
Fellows	1131	14	37	1	1	9	4	—	+ 38	1169
Associates	2501	140	102	—	11	2	5	36	+ 188	2689
Graduates	1396	168	88	2	22	—	5	101	+ 130	1526
Subscribers	430	16	—	—	27	4	4	2	− 21	409
Students	843	278	—	1	24	—	55	88	+ 122	955
TOTAL	6309	616	227	4	85	17	73	227	+ 445	6754

Inspectors. Several colleges have already submitted schemes for instrumentation courses.

Education

Postgraduate Training of Physicists. The Joint Committee of the Institute and The Physical Society set up in 1958 almost completed its work and expects to publish its report on the postgraduate training of physicists early in 1960. The Committee has obtained written comments from a large number of industrial scientists and has invited some industrialists and university physicists to attend meetings to present their views. For this purpose meetings of the Committee have been held in London, Cambridge, Edinburgh and Manchester.

The Teaching of Mathematics to Physicists. The Membership and Education Committee appointed a small panel at the end of 1958 to revise the well-known *Report on The Teaching of Mathematics to Physicists* and the panel decided that a fundamental re-writing was now desirable. The new report was published in January 1960.

International Conference on Physics Education. At the suggestion of the American Institute of Physics, representatives of six countries met at Konstanz, Germany, in July to consider the possibility of holding an International Conference on Physics Education. Arrangements have been made to hold this conference in Paris at the end of July 1960 under the sponsorship of The International Union of Pure and Applied Physics and with the support of Unesco and the Organization for European Economic Co-operation. The Institute was represented at the exploratory meeting by Mr. Clarke, *Deputy Secretary*, who was asked to act as secretary of the Conference. Attendance at the Conference will be restricted and the Institute has been invited to be the body which will select the six British representatives and the papers which will be offered from this country. The Board was glad to co-operate and to provide the Conference secretariat.

Science Masters' Association Panel on Physics Syllabuses. The Science Masters' Association set up a Panel to suggest revised syllabuses in physics for the Ordinary and Advanced Levels of the General Certificate of Education and asked the Institute to appoint a representative to it. Dr. L. R. B. Elton joined the Committee on behalf of the Institute and two other Fellows, Professor H. Lipson and Mr. N. Clarke also accepted personal invitations to serve on the Panel, which has held some of its meetings in the Institute's House.

Scientific Education of Physicists. A new edition of the booklet *The Scientific Education of Physicists* was published during the year. This pamphlet which gives guidance on training and a comprehensive summary of information about the physics departments of all the British universities and of recognized technical colleges appears to be much appreciated, judged by the continual demand for copies.

Conferences and Symposia

Symposium on " Current Developments in the Production of High Vacua." A one-day Symposium on " Current developments in the production of high vacua " was held in London on April 17 and was attended by about 250 people. The first session was devoted to getter-ion and ion-sorption pumps, the second to the production of high vacua in large equipment, and the third to short contributions on the analysis of residual gases in kinetic vacuum systems. A summarized account of the proceedings of the Symposium was published in the September issue of the *British Journal of Applied Physics.*

Conference on " Some aspects of magnetism." A residential Conference on " Some aspects of magnetism " was held in The University of Sheffield from September 22-24 and was intended mainly for persons working in the field. About 175 persons participated of whom nearly one-third came from oversea. The subjects covered at the Conference were :

(*a*) Fundamental theories of ferro-, ferri-, and antiferromagnetism, including magnetic structure.
(*b*) Theories of technical magnetization processes, including hysteresis, coercivity, anisotropy and directional effects.
(*c*) Theoretical and experimental studies of domain phenomena in bulk materials and thin films.
(*d*) Experimental and theoretical studies of antiferromagnetism in metals and non-metals.

A summarized account of the proceedings of the Conference is being published in the *British Journal of Applied Physics.*

Branch and Group Conferences and Symposia. The Branches and Groups again held a number of Conferences and Symposia and these are mentioned in that section of this *Report.*

Publications

The Journals. The increase in circulation of the *British Journal of Applied Physics* continued, but that of the *Journal of Scientific Instruments* showed a slight decrease for the first time for many years. The new arrangements for selling advertising space came into force in April.

Table 3 shows the amount of material submitted and published during the year, compared with the previous year. Of the 178 papers submitted to the *Journal of Scientific Instruments* during the year and the 131 papers to the *British Journal of Applied Physics*, 34 and 27 respectively were still under consideration at the end of the year.

The Journals Advisory Committee held its first annual meeting in May and received reports from the Steering Committees for the two journals. It agreed that the standard of the journals had been maintained and that the scope of the *British Journal of Applied Physics* should not be limited despite the introduction of several new journals specializing in particular branches of applied physics. On expert advice it was agreed that the indexes for both journals should revert to their old style although in a more comprehensive form, and that the indexes should be published with the March issue of the following year (instead of with the December issue as in the past).

The revised edition of *Notes for Authors* was published in May and was widely distributed and publicized in an effort to improve the preparation of the papers before submission.

The strike in the printing industry which occurred in the middle of the year caused long delays in the publish-

Table 3. *Contributions submitted and published*

	J.S.I.		*B.J.A.P.*	
	1958	*1959*	*1958*	*1959*
Extent of Journal (text pages)	*480*	512	*500*	544
Original papers (numbers) :				
Submitted	*183*	178	*143*	131
Accepted	*124*	97	*93*	71
Published	*110*	126	*89*	99
Special articles and conference reports published (numbers)	*3*	—	*11*	10
Laboratory and Workshop Notes (numbers) :				
Submitted	*102*	75	—	—
Accepted	*72*	45	—	—
Published	*75*	77	—	—
New Instruments, Materials and Tools :				
Items published	*88*	81	—	—
Notices of manufacturers' publications	*67*	—	—	—
Letters to the Editor published	*18*	12	*11*	15
Number of book reviews published	*26*	22	*121*	180

ing of the journals, but by the end of the year the special efforts of the editorial staff and printers had brought publication almost back to normal.

The Bulletin. The page size of the 1959 volume of the *Bulletin* was increased so as to be uniform with the Institute's two scientific journals. Although the volume consisted of 324 pages of text, about 22% more material was published than in the 336 text-pages of the 1958 volume. The usual lists of new elections, notices, reports of Branch and Group activities and summaries of contents of the scientific journals were published. 25 articles and reviews of 114 books were also included. A total of 388 advertisements of vacancies for physicists (of which many related to several vacancies) was included compared with 357 in 1958, and in June a special 14-page advertisement supplement dealing with courses in colleges of technology was issued.

Books. The sales of books taken over by Chapman and Hall Ltd., under the arrangement whereby they publish on behalf of the Institute, have been very satisfactory and the *Monographs for Students* series has proved particularly successful. Under this arrangement *Errors of Observation* (J. Topping), *Theory of Lenses* (E. W. H. Selwyn), *Fundamentals of Thermometry* (J. A. Hall), *Practical Thermometry* (J. A. Hall) and *Magnetic Circuits* (A. E. De Barr) have all been reprinted during the year. New titles in this series are under consideration and a substantial expansion is planned. One new volume, *Mechanical Design of Laboratory Apparatus* by H. J. J. Braddick is at press and two other volumes are in preparation.

The Design of Physics Research Laboratories (a symposium arranged by the London Home Counties Branch of the Institute) was published for the Institute in January and the second edition of *Physics as a Career* in September.

A Physics Anthology, a selection of articles that have appeared in the *Bulletin* was in its final stages at the end of the year and was due to be published in the Spring.

X-ray Diffraction by Polycrystalline Materials, first published in 1955 in the *Physics in Industry* series was being reprinted with revisions at the end of the year.

Annual Dinner

The Annual Dinner of the Institute was held at the Park Lane Hotel, London, on May 5 and was attended by 265 members and guests. The President was in the Chair and replied to the toast of " The Institute of Physics " proposed by Sir Keith Murray ; the reply to " The Guests " proposed by Mr. O. W. Humphreys was made by Sir Harry Melville.

Organization and co-ordination of Scientific Meetings

Groups. During the year the Meetings Committee, the setting up of which was reported last year, advised the Board on which of the various subjects suggested to it, conferences and symposia should be held.

In March the Board accepted the Committee's recommendations regarding the policy to be followed in respect of the activities of the Groups in relation to the general work of the Institute. Later in the year the Committee commenced its review of the work of each Group with the help and advice of representatives from the Group under review.

Consideration of proposals about other Institute meetings were postponed pending the completion of the proposed amalgamation with The Physical Society.

Electron Microscopy. At the suggestion of the Electron Microscopy Group the Board arranged for a meeting of representatives of sister Societies and Institutions interested in various aspects of electron microscopy to hold an exploratory meeting to consider matters of common interest. The meeting was held on December 10 in the Institute's House and made recommendations to the bodies represented about co-ordination of their meetings in this field in this country and about liaison with the International Federation of Electron Microscope Societies.

Stress Analysis. The Board accepted a suggestion of the Stress Analysis Group that a meeting of representatives of sister Societies and Institutions interested in various aspects of Stress Analysis should be held to consider international co-operation in this field. The meeting was arranged for early in 1960.

Joint British Committee for Vacuum Science and Technology. Following the Conference on High Vacua (noted above) various suggestions were made for arranging regular British meetings on vacuum science and technology, and for British participation in International Conferences in this field.

Following an exploratory meeting of representatives of Societies and Institutes in this country convened by the Institute, a "Joint British Committee for Vacuum Science and Technology" has now been formed. The Committee consists of representatives from ten Institutes and Societies and The Institute of Physics has agreed to provide the secretariat for the Joint Committee.

Professional matters

Enquiries. The Permanent Officers, often advised by the Honorary Officers or other Fellows of the Institute with special knowledge, have as usual dealt with a number of confidential enquiries concerning professional matters. These were similar to those of previous years, including particularly enquiries about terms of contracts of service, suitability of salaries for various posts, availability of courses at all levels and prospects for physicists at home and oversea.

Industrial Demand for Physicists and School Leavers. An enquiry was begun into the demand from industry for graduate physicists and for school leavers who will be given opportunities of studying part-time for qualifications in physics such as the Higher National Certificate. The Board is grateful to the large number of firms who have already supplied detailed information. It is hoped to be able to publish a summary of the information in 1960.

Medical Insurance Scheme. For the convenience of members, the Board of the Institute agreed to sponsor a Group scheme with the British United Provident Association. This provides significant advantages over individual membership, including a 20% reduction on the standard rates of subscription and the waiving of the normal waiting period of three months.

Proposed Amalgamation of the Institute and The Physical Society

The broad basis of a scheme for the amalgamation of The Institute of Physics and The Physical Society which was outlined in a circular sent to members last year, was widely approved by members. Accordingly the Board of the Institute and the Council of the Society set up a joint Committee to work out all the details, with financial and legal advice. The results of the Committee's deliberations, after approval by the Board and Council, were circulated to members on August 7 and received widespread approbation. Some useful comments and suggestions were received from members and as a result some small modifications were made to the proposals.

The final scheme was unanimously adopted at an Extraordinary General Meeting on December 1 which "requested the Board and Council to take the necessary action to implement the proposals for amalgamation" (a similar request was made by an Extraordinary General Meeting of The Physical Society held on November 27). Immediately after the General Meeting steps were taken to carry out the requests made at those meetings.

The Institute's House

The work on the mews premises which had been postponed for reasons of economy last year was completed and now houses the accounts and publications sales sections. The senior staff dining room, which had temporarily had to be used as an office, was thus released and was converted into a Committee/Dining Room. The furnishings and décor were provided by friends of the Institute and from the bequest of Mrs. Winifred Phillips, widow of Major C. E. S. Phillips, a former Honorary Treasurer. A plaque in the room acknowledges these gifts and serves as a reminder of the generosity of the donors and of the services to the Institute of Major Phillips, whose portrait is hung in the room. In addition, repairs and decorations were carried out to maintain the property in good serviceable condition.

The number of Institute meetings held in the House during the year is shown in Table 4.

Table 4. *Meetings held in the House*

	1957	*1958*	*1959*
Board and Committee meetings (including Branch and Group Committees)	75	90	81
Conferences and lecture meetings...	28	29	30
Social functions	14	15	18

Acknowledgements

Branch, Group and Conference Officers. The Board wishes to record its thanks to those members who have acted as Honorary Officers of the Institute's Branches, Groups and Conferences and who have thereby contributed greatly to the Institute's activities.

Meeting Rooms and Visits. The Board records its thanks to the many bodies which have generously allowed meetings of the Institute and of its Branches and Groups to be held on their premises.

Finance

The accounts are presented in the same way as in recent years but the proportional allocation between them of the costs of headquarters services and the House has been slightly changed as a result of re-examination. The final surplus for the year on the combined accounts (Institute and Endowment Trust Fund) is £656, which was a little less than had been hoped for, largely on account of additional expenditure required for the House.

The Institute of Physics Accounts

The Institute's accounts show a substantial increase in members' fees compared with the previous year. This is partly due to increase in numbers, and partly to the increase in the rates which became effective at the beginning of the year.

A sum of £500 was allocated by the Board some time ago from the bequest made to the Institute by the late Mrs. Winifred Phillips to be spent on some items for the House which would serve as a reminder of her generosity and of the services which her husband gave to the Institute as its Honorary Treasurer. As noted earlier in this report, this money was spent during the year on the décor and some of the furnishings of a Committee-Dining room ; and the Reserve Fund has been reduced by this amount.

Following the normal practice, funds have been transferred from the Institute's account to the Endowment Trust Fund account, thus providing a contribution from members' subscriptions towards the cost of the educational and scientific work, including the work of the Branches and Groups, carried out in the Institute's name through the Trust Fund. The amount for the year was £3,450.

The final surplus on this account of £25 is carried to the reserve fund.

Endowment Trust Fund Account

The surplus for the year on the publication business (which forms the major portion of this account) was substantially more than last year, as a result of the increase in the subscription rate to the Journals. The income from advertisements was, however, not as much as had been budgeted for, and this must be attributed in part to the prolonged strike in the printing industry. This surplus on the publications business together with the transfer from the Institute's account was only just sufficient to cover the cost of the scientific and educational activities carried out by the Fund for the Institute ; and the resulting surplus of £631 was carried to the balance sheet which further reduced the Fund's deficit.

Income Tax relief on subscriptions to Institute Journals

The Inland Revenue agreed that those members of the Institute whose annual membership subscriptions qualify for relief under Section 16 of the Finance Act 1958 and who pay an additional annual sum to receive the *Journal of Scientific Instruments* or the *British Journal of Applied Physics* or both could also be relieved under this Section in respect of the additional payment.

Benevolent Fund

During the year a sum of £936 was paid out for assistance to ten cases. Fortunately this sum continues to be less than the annual income so that the Committee is able to follow its policy of building up its capital reserves to enable it to give adequate help if and when circumstances arise that may cause more members or their dependents to need help.

Subscriptions and donations from members amounted to £955 compared with £781 the previous year. The Fund Committee once again records its thanks to them and to those who have provided the royalties from books. A further donation of £A200 was received from the Australian Branch's Special Fund which is greatly appreciated in view of the assistance which is being given to some Australian members' dependents. The Fund received a further payment of £258 in respect of tax recovered on payments made by the Trust set up under the will of the late Mrs. Phillips.

A further 80 members have been good enough to sign seven-year covenants to subscribe to the Fund thus enabling it to recover income tax paid on their donations.

The Fund Committee wishes again to record its thanks to those members who have investigated cases on its behalf or have acted as trustees of money provided from the Fund.

Branches and Groups

Annual Conference of Branch and Group Officers. The 16th Annual Consultative Conference of the Honorary Officers of U.K. Branches and Groups was held in the Institute's House on May 6. The President reported on the progress of the negotiations for the amalgamation of the Institute with The Physical Society and outlined the Board's proposals for submitting the amalgamation scheme to members. The proposed procedure was approved by the Conference. The Chairman of the Meetings Committee (Dr. R. W. Sillars) reported on the recommendations it had made to the Board regarding the activities of the Groups in relation to the general work of the Institute. His statement was welcomed by the Conference and a general discussion followed in which some of the problems being faced by Groups were mentioned and possible ways of dealing with them discussed.

Other items reported upon and discussed concerned salary surveys, a new list of members, notes for the guidance of Branch and Group Officers, and National Certificates in Applied Physics.

The Branch and Group Officers named below were serving at December 31, 1959 :

Australian Branch : *President :* Professor H. C. Webster. *Vice-President :* Dr. J. L. Pawsey. *Honorary Treasurer :* Dr. J. S. Rogers. *Honorary Secretary :* Dr. J. K. Mackenzie. (513 members.)

Two Conferences were held during the year in Melbourne, the second " Conference on Contemporary Optics " on February 25-27 and the " Solid State Physics Conference " on August 17-21. Both Conferences were a great success and were attended by scientists from all parts of Australia ; the latter Conference attracted 17 scientists from oversea.

A new Division has been formed in the Australian Capital Territory and the other Divisions in the different states have again held many meetings. In addition, the Solid State Physics Group is active in N.S.W. and the third " Einstein Memorial Lecture " was delivered in Adelaide.

The Victorian Division continues to support the " Science and Technology Careers Bureau " and the Branch is represented as follows :

Australian National Committee on Illumination	Mr. W. R. Blevin
National Association of Testing Authorities...	Dr. N. B. Lewis
Australian Journal of Physics Advisory Committee	Dr. G. H. Briggs
Australian National Committee of U.N.E.S.C.O. for the Natural Sciences	Dr. G. H. Briggs
Conjoint Board of the College of Radiologists of Australasia and the Australasian Institute of Radiography ...	Mr. D. J. Stevens
The Australian National Committee on Computation and Automatic Control ...	Dr. D. W. Posener
Delegates to the Council of A.N.Z.A.A.S.	Professor H. C. Webster Professor C. J. B. Clews Dr. R. W. Crompton

Malayan Branch. *Chairman :* Mr. Y. S. Hon. *Honorary Secretary-Treasurer :* Dr. Y. K. Lim. (22 members.)

The arrangement whereby members may attend the colloquia in the Physics Department of the University of Malaya has continued. The Annual General Meeting of the Branch was held on September 4 in Singapore.

Liverpool and North Wales Branch. *Chairman :* Mr. F. I. Hurley. *Honorary Secretary :* Dr. A. Ashmore. (324 members.)

During the past year seven lectures have been held in Liverpool and one in Bangor. From its inception until this summer, the Branch has held its Liverpool meetings in the Department of Electrical Engineering but since then it has transferred to the recently completed Chadwick Physics Laboratories. The average attendance has been around 50 though occasional lectures have attracted a larger audience.

In November, the first social evening was held, at which Dr. J. M. A. Lenihan and Mr. Seumas McNeil of Glasgow spoke on " The Physics of Bagpipes " and with Mr. McNeil's superb illustrations on that instrument and the buffet supper later, the meeting was enjoyed by members and their guests alike. Another meeting was organized jointly with the Student Physical Society of the University of Liverpool.

The Branch has continued to operate the " School Scheme," by which local firms supply lecturers to give talks at schools in the district on the kind of work in which physicists in industry are engaged. Over 30 such visits have been arranged for the current academic session. It is believed that the venture has been successful and plans are in hand to improve the service.

London and Home Counties Branch. *Chairman:* Professor A. M. Taylor. *Honorary Secretary :* Mr. D. T. R. Dighton. (2809 members.)

Six lecture meetings were held during the year. The first was an address on " Controlled thermonuclear reactions " by the President of the Institute, and was particularly well attended. One lecture was repeated in Bournemouth, jointly with the local branch of the Royal Institute of Chemistry.

As in recent years, spring and autumn visits have been held. In both cases the visits have been followed by a lecture by a member of the Establishment visited. In April a party visited the Mining Research Establishment at Isleworth and in October a large party visited the Research Laboratories of the General Electric Co. Ltd.

The Branch Summer Meeting was held in June, when a large group of members visited the Royal Observatory, Hurstmonceux, and were able to examine telescopes and equipment associated with time measurement.

In addition, a one-day symposium was held jointly with the Acoustics Group of The Physical Society in Southampton in April.

Manchester and District Branch. *Chairman :* Professor H. Lipson. *Honorary Secretary :* Dr. J. E. Geake. (406 members.)

Seven lecture meetings were held, including one on " The Aesthetic Design of Scientific Instruments " by Mr. R. H. Litherland from the School of Art, Salford. A special afternoon meeting for students only, on "What it is like to be a physicist," was attended by over 100 students.

The Branch annual dinner in March was held at the Manchester College of Science and Technology. The principal guests were Professor and Mrs. A. C. B. Lovell and Professor J. G. Wilson. For the first time, those present included members' wives and other guests.

The Summer Visit in July was to the Jodrell Bank Experimental Station. After an introductory talk by the Director, the 250 ft. radio telescope was inspected and some of the laboratories were visited.

Midland Branch. *Chairman :* Dr. J. H. Davis. *Honorary Secretary :* Dr. W. T. Roberts. (642 members.)

Five lectures were held in Birmingham and visits were made to the British Thomson-Houston Group Research Laboratory at Rugby and the British Ceramic Research Association at Stoke, both visits being followed by talks.

The President of the Institute spoke to the Branch about the life and work of his father, Sir J. J. Thomson. The particular interest in metals, in this area, was evident when an audience of over one hundred listened to Professor Mott's talk on " Dislocations." Average attendance at the seven lectures was fifty-six, a considerable increase over the figure for last year.

The sixth Branch annual dinner was held in the Students Union of the University of Birmingham, when our guests of honour were Mr. O. W. Humphreys, Professor M. R. Gavin and Dr. R. J. Wakelin.

North-Eastern Branch. *Chairman :* Dr. O. P. T. Kantorowicz. *Honorary Secretary :* Dr. W. D. Corner. (176 members.)

The Branch held eight lecture meetings, six in Newcastle-upon-Tyne, one in Durham and one in Seascale. A lecture by Professor H. S. W. Massey on " The Scientific Uses of Rockets and Satellites " attracted a record audience of 200.

The Summer Meeting took the form of a visit to the Billingham works and laboratories of Imperial Chemical Industries Ltd. in June.

A Branch dinner was held in April and this was so successful that it is hoped to make it an annual event.

Scottish Branch. *Chairman :* Dr. G. A. P. Wyllie. *Honorary Secretary :* Dr. A. R. Boyle. (298 members.)

Twenty-four lectures were given at the various centres in Scotland as follows : Edinburgh (7), Glasgow (8), St. Andrews (2), Aberdeen (4), Dundee (2), Dounreay (1).

They covered a wide range including : Correlation between Photons and Applications to Astronomy, Transmission of Electrical Impulses along Nerve Fibres, Recent Advances in Nuclear Magnetic Resonance, Structure and Evolution of the Galaxy.

The President of the Institute addressed the Branch in October on " Thermonuclear Processes."

South Wales Branch. *Chairman :* Dr. M. R. Hopkins. *Honorary Secretary :* Dr. H. O. Puls. (277 members.)

Six evening meetings were held : 3 in Cardiff, 2 in Swansea, and 1 in Aberystwyth. The subjects included : High Energy Particle Accelerators, Scientific uses of Digital Computers, Molecular Amplifiers and

Oscillators, Introduction to Electrical Logic (or a treatise on Boolean algebra), Physics and the Artist, Physics in the Safety in Mines Research Establishment, and Nuclear Magnetic Resonance in Liquids.

Sir Harry Melville spoke on the work of the D.S.I.R. Research Establishments to a joint meeting of the Scientific Societies of South Wales and Monmouthshire.

South-Western Branch. *Chairman :* Professor S. H. Piper. *Honorary Secretary :* Dr. S. H. Ayliffe. (265 members.)

Eight meetings have been held: Bristol (5), Exeter (2), and Weymouth (1). The subjects of the lectures included Radio Astronomy, Liquid Structure, Relativity, Space Research, Cybernetics and the Biological Hazards of Radiation. In addition, the Branch held a Summer Meeting at the Royal Military College of Science at Shrivenham. The visit included demonstrations of the work of the College and several members of the College staff contributed short lectures. These were followed by an address by Dr. Wynn Williams on " Electrical Logic."

Yorkshire Branch. *Chairman :* Dr. A. B. D. Cassie. *Honorary Secretary :* Dr. M. McCaig. (270 members.)

During the year five meetings were held: Sheffield (2), Hull (1), and Leeds (1). In addition, one meeting was held jointly with the Leeds Astronomical Society. The Summer Meeting took the form of lunch in Buxton followed by a visit to the Ferodo Laboratories at Chapel-en-le-Frith. During the year new Branch rules were adopted.

Applied Spectroscopy Group. *Chairman :* Dr. A. C. G. Menzies. *Honorary Secretary :* Mr. F. W. J. Garton. (309 members.)

The programme of the Group has consisted of two afternoon meetings and one all-day Symposium. The first was held in February and was a Colloquium on " The Spectrographic Analysis of Powders." The second, an all-day Symposium on " Reviews of Recent Developments in Spectroscopy," was held at the Royal Society of Arts in May and papers on various aspects of spectroscopy were read. In December, a paper on " Time-resolved Spectroscopy " was read by Dr. H. Kaiser.

Education Group. *Chairman :* Mr. G. W. Warren. *Honorary Secretary :* Mr. T. H. Tyler. (519 members.)

Two discussion meetings, three lecture meetings and the Easter Conference were held in the Institute's House. The subject of the Conference was the " Teaching of Science to Children up to the Age of Fifteen."

The Summer Meeting took place at Cambridge and a tour was made of the Cavendish Laboratory and the Radio Astronomy Observatory.

Electronics Group. *Chairman :* Dr. T. B. Rymer. *Honorary Secretary :* Dr. C. A. Hogarth. (790 members.)

During the year the Group fulfilled its function of acting as a forum for the study and exchange of ideas about the physics of electronic devices. Attendance at the six lectures, all in the Institute's House, was very satisfactory.

In October a two-day meeting on " Noise in Electronic Devices " was held at the Services Electronics Research Laboratory at Baldock. About 100 people attended this Conference and were able to take the opportunity to see some of the work of the Laboratory.

Electron Microscopy Group. *Chairman :* Mr. A. W. Agar. *Honorary Secretary :* Dr. R. Reed. (387 members.)

In July, at the University of Exeter, the Group held a Conference which was attended by over two hundred persons.

With the co-operation of the manufacturers, a new list of users of the electron microscope was compiled and issued to members.

The Group Chairman presided at an exploratory meeting of representatives of Institutes and Societies, called by the Board to discuss matters of liaison in the field of electron microscopy (*see above*).

Two Newsletters were circulated to members during the year.

Non-Destructive Testing Group. *Chairman :* Mr. B. R. Byrne. *Honorary Secretary :* Dr. P. Lord. (454 members.)

The Group has seen a steady expansion of its activities over the past year in a continued attempt to cater for varied interests.

There have been two Conferences, one in March— " What Industry Requires of Non-Destructive Testing," which attracted a large attendance and another of more general interest in the Lake District, including a visit to Calder Hall.

Five lectures at the Institute's House have ranged from " Triboelectrics " to " The role of Physics in the Investigation of Heart Disease." As before, there was a highly successful lecture in the provinces, on this occasion in Sheffield, when Professor G. A. Homes presented a paper on Relationships between Physical and Structural Properties.

The second Dinner Meeting took place in January at which Mr. S. Rhees-Jones talked to the members of the Group and their ladies on " Testing of Works of Art and the Detection of Forgeries."

The first joint Conference with the Société Française de Métallurgie was commemorated with the presentation of a rose bowl in Paris by representatives of the Committee and the foundations laid for a reciprocal visit to this country in 1960.

Stress Analysis Group. *Chairman :* Mr. A. F. C. Brown. *Honorary Secretary :* Mr. C. D. Pomeroy. (233 members.)

The Group Committee undertook a new venture in April ; it arranged a 3-day International Conference on Stress Analysis in Delft, Holland. This was rendered possible by the kind invitation of Professor Boiten and his colleagues in the Netherlands Instituut T.N.O. who undertook all the local arrangements. 51 papers on a wide range of subjects in English, French and German were discussed at this Conference which was attended by representatives from most European countries. Publication of some of the papers in book form has been arranged. As a result of this meeting it is hoped that regular International Conferences will be held.

A 2½-day Conference was held in the University of Birmingham in September. Sixteen papers were presented on a wide range of topics. The subjects included : Dynamic Stress Measurements and Photoelastic Analysis, Analogue Techniques, Brittle Fracture and the Moiré Method. A discussion on Strain Measurement at High Temperatures was also held. During this conference visits to the Dunlop Research Centre, Joseph Lucas, Ltd., and Henry Wiggins and Co., took place.

X-ray Analysis Group. *Chairman:* Dr. C. W. Bunn. *Honorary Secretary :* Dr. P. T. Davies. (485 members.)

Two two-day Conferences were held during the year. At the spring Conference in the School of Chemistry of the University of Leeds, there were two sessions on " Clay minerals " and one on " Biological Fibres." The autumn Conference was held in London at The Institution of Civil Engineers, and the subjects were " Structure Analysis " and " Experimental Techniques"; the Conference was attended by 168 persons.

Collection of crystallographic data for the A.S.T.M. X-ray Powder Data File and for a new edition of the Single-Crystal Index has continued at University College, Cardiff, and at the University of Leeds. Two members of the Equipment Sub-Committee, Dr. E. G. Steward and Dr. U. W. Arndt, are also members of the Apparatus Commission of the International Union of Crystallography ; they attended a meeting of the Commission in Stockholm in June.

The revised Constitution and Rules of the Group were adopted, and received the approval of the Board of the Institute.

Three Newsletters were circulated to members during the year.

Extracts from Reports to the Board of representatives and nominees on joint and other Committees and organizations

The Board records its thanks to the several members who have represented the Institute on many bodies and thus helped in the " advancement and diffusion of a knowledge of physics." The large amount of work of a routine nature carried out by these committees is not reported below, where only matters likely to be of special interest to members are noted.

Parliamentary and Scientific Committee. The General Committee met nine times for lecture and discussion meetings on topics of the day among which were : The Promotion of Nuclear Energy Development on the Continent and the Work and Plans of the National Research Development Corporation. Visits were paid to four scientific and technological establishments.

In July, the Chancellor of the Duchy of Lancaster, The Rt. Hon. Dr. Charles Hill, addressed a special meeting of the Steering Committee on the Government's plans to increase the sale and augment the availability of books and technical and scientific publications oversea. The address was followed by a discussion aimed at elucidating the statement he had made in the House of Commons on this important matter.

At the Annual Luncheon in February the Prime Minister, the Rt. Hon. Harold Macmillan, was the Guest of Honour.

In the last Annual Report, reference was made to the evidence given by this Committee to the Pritchard Committee set up by the Government to review the rating of property occupied for charitable purposes and to consider the provisions of the Scientific Society's Act, 1843. The Report was issued in August and subject to certain reservations, the Parliamentary and Scientific Committee welcomed the recommendations in the Report. It has submitted its observations to the Minister of Housing and Local Government and is watching its developments closely. The Committee noted with great interest the appointment of a Minister for Science and it is hoped that he will address the General Committee at one of its meetings in 1960.

The parliamentary members of the Committee have again taken part in debates concerned with scientific and technological subjects and have asked a number of questions in the House of Commons on matters in which the Committee had particularly interested itself.

Royal Society's (British) National Committee for Physics. One meeting has been held, and the rest of the business of the Committee conducted by correspondence. Various recommendations were made or endorsed for international conferences, including a Symposium on lattice defects and the strength of solids, to be held in Cambridge between August 22 and 24, 1960. An International Geophysics Committee (C.I.G.) has been formed.

The British Committee has supported a suggestion that in future the membership of each Commission should be limited to six or seven, not more than one from each country, together with corresponding members. I.U.P.A.P. has established a new Commission on spectroscopy to replace the former Joint Commission, and Dr. G. B. B. M. Sutherland has been appointed Secretary of the Commission. A meeting of the International Optical Commission was held in Stockholm in August, 1959. The next general assembly of I.U.P.A.P. is to be held in Ottawa in September, 1960.

Royal Society's (British) National Committee for Crystallography. The Committee met twice. At a meeting in March, arrangements were considered for the forthcoming Leningrad and Stockholm meetings, for the Cambridge (1960) Congress, and for the preparation of a new edition of the World Directory of Crystallographers. In October the Committee further considered the last two items, and a number of matters in connexion with *Acta Crystallographica* and the International Union of Crystallography.

British National Committee for High Speed Photography. The formation of this Committee was envisaged at the 4th International Congress on High Speed Photography in Cologne in 1958. In this first year of activity, two one-day Conferences have been held. The first was held at the Atomic Weapons Research Establishment at Aldermaston in July in conjunction with the Optical Group of the Physical Society. The second was held in September at Queen Mary College, London, on " High speed photography in industry." Both occasions were most successful and well-attended. It is planned to continue these one-day functions at intervals of about six months, each occasion covering a special aspect of the subject.

British National Committee for Non-Destructive Testing. The Committee met five times and there were a further six meetings of its sub-committees. Much of its work has been concerned with the Third National Conference on Non-Destructive Testing to be held in Tokyo in March, 1960. Considerable attention has also been devoted to the investigation into the needs of industry following a meeting organized earlier in the year by The Institute of Physics' Non-Destructive Testing Group on this subject. Other subjects considered have included training, special courses and future symposia.

Board of The British Nuclear Energy Conference. The Board met four times during the year and received reports on papers and meetings arranged by the constituent bodies and others, on nuclear energy and ancillary subjects. A selection of these was published in its *Journal of The British Nuclear Energy Conference.*

To help scientists and engineers to assimilate the large amount of material (over 2,000 papers) produced for the second International Conference on " The peaceful uses of atomic energy " (held in Geneva in September, 1958) the Conference Board arranged a one-day lecture Symposium which took place in London on March 13. The lectures were published in the Conference's *Journal.*

The Board set up a Panel to assist constituent societies and others to co-ordinate the arrangements for meetings on nuclear energy and ancillary subjects.

Joint British Committee for Vacuum Science and Technology. The establishment of this Committee is referred to above. It held its first meeting on October 26 and arranged for the periodical circulation of information about meetings in the whole field of vacuum science and technology, to constituent bodies. Arrangements were made for maintaining liaison with the International Organization for Vacuum Science and Technology and with other national vacuum societies. Consideration was also given to standardization and testing of apparatus.

Science Abstracts Management Committee. The Committee held three meetings during the year. The principal concern continued to be the expansion of the volume of abstracts, which was continuing progressively, and the basis on which selection should be carried out. Informal discussions has taken place with the American Institute of Physics on these questions.

The Royal Society's Paul Instrument Fund Committee. Sir Frank Smith, the Institute's representative, has been Chairman of the Committee since it was set up in 1945. He has now resigned, and the Committee has recorded its warm appreciation of his services. The Committee has considered a number of applications for grants during the year, and has made various awards.

Ministry of Labour and National Service's Panel on Special Regulations for Protection against Ionizing Radiations. During 1959 ten meetings of the Committee were held. Discussion has centred chiefly on regulations governing the use of unsealed sources of ionizing radiations. A preliminary draft has now been completed, and this should shortly be ready for circulation for comment to industry and other interested organizations. The code of regulations on the use of sealed sources, first issued in July, 1957, has been revised to take account of the latest recommendations of the International Commission on Radiological Protection, and was published in January, 1960.

Joint Committee for Chemical Analysis by X-ray Diffraction. A further set of data cards (the 9th) and a further " Comments " booklet (the 5th) were published during the year. The Editors of the A.S.T.M. X-ray Powder Data File arranged to meet with others interested in the course of the Congress of the International Union of Crystallography to be held in Cambridge in August, 1960.

The Physical Society's Exhibition Committee. The Committee met three times and discussed and approved the arrangements for the January, 1960, Exhibition in the Royal Horticultural Society's halls, the discourses to be given and the craftsmanship and draughtsmanship competition. The attendance at the 1959 Exhibition (26,300) exceeded that of all the Society's previous Exhibitions. A small group of Committee members toured the exhibition prior to its opening to note infringements of the rules of presentation.

Special Physical Society Exhibition Sub-Committee. At the invitation of the Council of The Physical Society two representatives of the Institute attended a meeting of a special sub-committee it had set up to consider various suggestions it had received concerning the future arrangements for the Exhibition.

National Council for Technological Awards : Board of Studies in Technologies other than Engineering. Recognition has been given to courses leading to Dip. Tech. (Applied Physics) at the Bradford Institute of Technology and at the Borough Polytechnic. A number of examination arrangements have been received and approved.

During the year there were five meetings of the Board of Studies in Technologies other than Engineering, and two meetings of the Applied Physics Subject Panel.

Science Masters' Association Panel for Consideration of School Examination Syllabuses in Physics. There have been five meetings of the Panel including a two-day meeting at Malvern College. A draft for an O-level syllabus has been prepared and circularized to all S.M.A. members for comment. In drawing it up, the panel had in mind the topics about which the educated citizen who is not necessarily a science specialist, should have some knowledge on leaving school. Good progress has been made with the A-level draft syllabus and it is expected that it will be circulated to members within the next few months. Some of the Panel meetings have been held in the Institute's House.

Court of the University of Exeter. The Court has noted steady development of the University. There are over 200 students reading Physics, including ten full-time research students and 76 in the Honours School.

The Court of Governors of the Manchester College of Science and Technology. The Court has dealt with the usual routine business and sought authority for an increase in the membership of the Court and of the Council by adding to the number of industrial representatives.

Governing Body of Brunel College of Technology. During the past year the first candidates sat for the Dip. Tech. examination in Applied Physics. Of a total of four, all passed, three of them with first class honours. In the opinion of the external examiners, these latter were quite up to the standard of university first class honours graduates in physics. They enjoyed far more individual attention from the College staff than is to-day possible in any university and it remains to be seen whether such a high standard can be maintained when student numbers increase. The standard of the projects carried out by the students in their final year was also very high.

Governing Body of Norwood Technical College. Proposals for further extensions of the College are under review. An effective Consultative Committee for Physics is in being.

Governing Body of Rutherford College of Technology. The Governing Body has been principally concerned with the staffing and equipment of the new building. Members of the Hives Council visited the College in connexion with the Council's recognition of courses.

Applied Science Advisory Committee of the Birmingham College of Technology. The Committee has considered various matters connected with sandwich, postgraduate and other courses. The Committee also discussed and accepted a report of a sub-committee dealing with the intake of students to courses with Physics as a main subject. The Institute's representative has reviewed and approved a schedule of apparatus required by the Department of Physics to equip additional accommodation now under construction.

Science Advisory Committee of Blackburn Municipal Technical College. The Committee has considered several suggestions for advancing the work of the Department and has recommended additional senior appointments. A new Science Department with much new equipment was brought into operation during the course of the year.

Science Advisory Committee of Ewell County Technical College. The Ordinary National Certificate course in Applied Physics is rapidly developing and good results were achieved in the 1959 examinations.

The Advisory Committee for Applied Physics of Kingston Technical College. The Committee reviewed the syllabus, entry, and results of the Applied Physics courses, and advised the Governors on equipment of the laboratories. A postgraduate standard electronics course was particularly successful.

Science Advisory Committee of the Merseyside and District Advisory Council for Further Education. The work of the Committee was concerned largely with the consideration of various courses. New ones were considered covering a wide field.

Monmouthshire Technical Education Sub-Committee. This sub-committee met eight times. The Physics courses for the Higher National Certificate have now been transferred from Crumlin Technical College to the new joint Newport and Monmouthshire College of Technology in Newport.

Science Advisory Committee of Poole College for Further Education. Useful discussions with the Heads of the Secondary Schools in the area have taken place.

Science Advisory Committee of the Governing Body for Technical and Further Education in the Slough Area. The College has enjoyed considerable expansion of its premises. Applied Physics, at present offered up to the S.2 year only, will be continued to Ordinary National Certificate level and a " bridge " class will be formed to allow G.C.E. students to enter a Higher National course in Applied Physics. Eventually it is proposed to offer the Higher National Certificate course in Applied Physics, subject to approval by the Ministry and the Regional Advisory Council. Amongst a number of postgraduate short courses which have been held, there has been one of six lectures on applied rheology. Approval has been received for a course on radio isotope technology.

Advisory Sub-Committee for Applied Physics of the Welsh College of Advanced Technology. In common with the experience of some other Colleges, difficulty of recruitment has so far prevented the starting of the course for the Dip.Tech (Applied Physics). The retirement of Mr. W. Somerville Vernon, head of the Department of Applied Physics for 34 years, was noted by the sub-committee with regret.

The Advisory Panel for Applied Physics of the West Midlands Advisory Council for Technical, Commercial and Art Education. The Panel held its first meeting during 1959, at which the Institute's representative was appointed Chairman. The general lines of its future activities were discussed, and, in particular, Applied Physics courses in the region were surveyed.

Advisory Panel for Physics of the Yorkshire Council for Further Education. The Panel considered in some detail the effects on technical colleges of proposals for limiting and eventually discontinuing degree courses. Attention was given to the high wastage from part-time courses, and to research in technical colleges. The Panel was able to contribute usefully and a resolution on the realistic provision of financial aid and other support to members of college staffs carrying out research was submitted to the Academic Board.

Advisory Committee on Industrial Radiography of the City and Guilds of London Institute. A sub-committee investigated the amending of examination syllabuses to attract entries possibly by extending the course to 4 years with an intermediate award at the end of the second year. The sub-committee also sought to include a section for service engineers (at the request of the Association of X-ray Technology) ; it appears that there is difficulty about preparing a suitable course at a lower level which might lead to a more advanced certificate at the present level.

BRITISH STANDARDS INSTITUTION'S COMMITTEES

Instrument Industries Standards Committee. Proposals for new revised or international standards have been before this Committee and its sub-Committees covering a wide field including terminology and symbols for instruments, dimensions for instruments, flow measurement, temperature measurement, pressure gauges, navigational instruments, revolution indicators and recorders, optical instruments, time measurement instruments, pivots and jewels for instruments, graduations for instruments, and instruments for measuring level of liquid in tanks.

The Committee also considered a report on standardization in connexion with the Common Market and the European Free Trade Area.

Technical Committee on Abbreviations and Letter Symbols. This Committee has continued its work of co-ordinating the symbols and abbreviations proposed by B.S.I. Committees with each other and with those proposed by the International Standards Organization. It has been specially concerned with the revision of B.S.1991, *Part 1:*

General which was first published in 1954. It is hoped to publish four new parts of B.S.1991, *Letter Symbols. Signs and Abbreviations* during the first half of 1960, It is planned at the same time to issue an Amendment Sheet giving the more urgent corrections required to bring *Part 1 : General* up to date and into consistency with the new parts. Upon publication of the new parts, a comprehensive revision of *Part 1* will be undertaken.

Good progress has been made in the work of the Symbols Committee of the International Electrotechnical Commission (I.E.C.).

Technical Committee on Glass for Protection against Ionizing Radiation. The Committee agreed that a B.S.I. specification for the protective power of lead glass should be described in terms of lead equivalent thickness for X-rays generated at 150kV and that absorption measurements should be made with a constant potential source of heterogeneous radiation. Tests of this kind are being carried out. Proposals for protective glasses for high energy radiation are also in preparation.

Sub-Committee on Glossary of Terms used in Nuclear Science. Wide interest has been shown in the circulation for comment of the draft Glossary, and an unusually large number of comments have been received from specialists in several organizations. Co-ordination between this Sub-committee and the B.S.I. Committee concerned with the International work on nuclear energy is being maintained.

Panel in Pocket Ionization Chambers and Dosemeters. Interest in the preparation of standards for ionization quartz fibre pocket dosemeters has been renewed and a draft specification has been prepared.

Letters to the Editor

What is a Physicist ?

Professor Lipson has certainly set up a most interesting target to shoot at with his remarks on theoretical physics in the December issue. It is probably more valuable, however, to use his remarks as a base upon which to build a clear idea of the nature of the link between mathematics and physics. Certainly such a discussion must bring in the names of two famous men on the cover of the *Bulletin :* Newton and Maxwell.

Even if we admit that J. J. Thomson is to the experimental side of, e.g. Dirac, it is not fair to Dirac to think of him merely as an applied mathematician. An applied mathematician is generally concerned with developing a basic theory further in mathematical terms, but the essence of Dirac's work is that he is mainly concerned with setting up the fundamental axioms of a theory, and great physical insight is required to set up such axioms, while it is quite true that to develop them further, beyond the point of first experimental verification, is mainly a mathematical task.

It is the insistence of the theorist on experimental verification as the final criterion, rather than mathematical beauty, that marks a definite borderline : and on the physics side of the borderline we find at least all the great natural philosophers, including Newton, Maxwell, Einstein, de Broglie, Dirac, Pauli, Yang and Lee, and men of the type of Bondi and Hoyle or G. I. Taylor.

The line between " experimental " and " theoretical " physics can also be drawn at the point where a physicist is merely concerned with proving or disproving a given theory and does not attempt to set up his own theory of what is happening. A great many experimental physicists never pass this line, but some of the best experimenters work on either side of it.

I think it is much more useful to regard theoretical physics and applied mathematics as two halves of a bridge connecting pure mathematics and experimental physics, and to view this bridge as a structure on its own, forming a distinct part of the larger landscape of scientific thought.

K. Metzer (*Graduate*).

30 Daleham Gardens,
London, N.W.3.

The value of a physics degree

The topic of the education and training of physicists is one which occupies a considerable proportion of your pages. This leads me to write as one who is still at the " receiving end," i.e. reading for a Ph.D. in physics.

At a recent reunion of several colleagues who started on their first degrees at the same time as myself, ideas were exchanged on the value of a B.Sc. Special in physics. While it was generally agreed that this was a useful paper qualification many doubts were expressed as to its practical value. At least two were seriously contemplating an M.Sc. in mathematics, two more an I.E.E. Associateship, and one other a qualification in mechanical engineering. My own work can only be described as the application of electronic engineering to problems in radiation chemistry.

An interesting question can thus be posed. Is the syllabus drawn up by the universities completely out of touch with modern requirements, or are properly taught graduates being appallingly mis-used by those "outside." Experiences of those in a similar position should prove most enlightening.

J. A. Simmons (*Graduate*).

Physics Department,
Medical College of St. Bartholomew's Hospital,
London

THE INSTITUTE OF PHYSICS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1959

1958 £		£
	To Office and general expenses:—	
5,126	Salaries and National Insurance	7,169
266	Staff superannuation	529
1,314	Rent, rates, heating, cleaning, maintenance, etc. ...	3,119
1,360	Board, Committees' and Officers' travelling expenses	1,472
709	Printing and stationery	1,009
1,819	Bulletin	2,108
730	Postages and telephones	1,061
384	Miscellaneous expenses	658
11,708		17,125
337	,, Depreciation of furniture, fittings and office machinery	910
378	,, Amount written off expenditure on alterations, improvements and adaptations to House	378
985	,, Leasehold Redemption Policy	985
4,050	,, Grant to Endowment Trust Fund	3,450
34	,, Balance being excess of income over expenditure carried to Reserve Fund	25
£17,492		£22,873

1958 £			£
15,898	By Members' subscriptions, entrance and other fees ...		21,180
60	,, Dividends and interest less tax		178
	,, Contribution from Endowment Trust Fund for alteration of premises, depreciation of furniture, fittings, office machinery and leasehold redemption policy:—		
850	Charged to cost of publications	758	
425	Charged to other work	757	1,515
259	,, Income tax recovered		—
£17,492			£22,873

THE INSTITUTE OF PHYSICS

BALANCE SHEET, 31st DECEMBER, 1959

1958 £		£	£
	LIFE MEMBERSHIP FUND:—		
	As at 31st December, 1958	4,722	
	Less Transfer to Reserve Fund in respect of deceased members	63	
4,722			4,659
	RESERVE FUND:—		
	As at 31st December, 1958	23,364	
	Add transfer from Life Membership Fund ...	63	
	Sinking Fund for Leasehold Property ...	985	
	Transfer from Income and Expenditure Account	25	
		24,437	
	Less Transfer from Phillips Bequest	500	
23,364			23,937
	CURRENT LIABILITIES:—		
	Payments received from members in advance ...	458	
	For expenses	2,826	
2,796			3,284
£30,882			£31,880

G. P. THOMSON, *President.*
J. TAYLOR, *Honorary Treasurer.*

1958 £		Cost to 31/12/58 £	Additions during year £	Depreciations to 31/12/58 £	Depreciation during year £	£
	FIXED ASSETS:—					
1,013	FURNITURE, FITTINGS AND OFFICE EQUIPMENT ...	7,277	2,864	6,264	910	2,967
5,381	ALTERATIONS, IMPROVEMENTS AND ADAPTATIONS OF PREMISES ...	10,289	—	4,908	378	5,003
6,394						7,970
	CURRENT ASSETS:—					
611	STOCK ON HAND—STATIONERY					739
610	DEBTORS—SUNDRY ACCOUNTS					933
7,997	DUE FROM ENDOWMENT TRUST FUND					4,508
93	SUBSCRIPTIONS IN ARREARS					132
	INVESTMENTS:—					
4,932	Quoted				4,932	
500	Unquoted				500	
5,432	(*Estimated market value at 31st December, 1959, £5,052*)					5,432
8,865	LEASEHOLD REDEMPTION POLICY					9,850
880	BANK BALANCE AND CASH IN HAND					2,316
£30,882						£31,880

Report of the Auditors to The Members of The Institute of Physics

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account have been kept by the Institute so far as appears from our examination of those books, and proper returns adequate for the purposes of our audit have been received from Branches of the Institute not visited by us. We have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of the Institute. In our opinion and to the best of our information and according to the explanations given to us the said accounts give the information required by the Companies Act, 1948, in the manner so required and the Balance Sheet gives a true and fair view of the state of the Institute's affairs as at 31st December, 1959, and the Income and Expenditure Account gives a true and fair view of the excess of income over expenditure for the year ended on that date.

Spencer House, South Place, London, E.C.2.
10th February, 1960

KNOX, CROPPER, GEDGE & CO., *Chartered Accountants.*

THE INSTITUTE OF PHYSICS—ENDOWMENT TRUST FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1959

1958 £		£
1,183	To Graduate and National Certificates examination ...	1,719
2,826	„ Expenses of Branches and Groups	2,931
121	„ Conference expenses	238
642	„ Educational work, booklets and reports	828
36,508	„ Cost of production and distribution of publications sold	33,755
8,390	„ Proportion of overhead charges in connection with work carried on by the Trust	13,530
425	„ Proportion of depreciation, alterations and Redemption Fund Account	757
—	„ Balance being surplus carried to Trust Fund ...	631
£50,095		£54,389

1958 £		£
1,338	By Fees for examinations	1,538
—	„ Donations	147
1,266	„ Interest	1,145
41,360	„ Receipts from publications including advertisements	47,394
4,050	„ Grant from Institute of Physics	3,450
319	„ Non-members' conference fees	715
1,762	„ Balance being deficit carried to Trust Fund	—
£50,095		£54,389

BALANCE SHEET, 31st DECEMBER, 1959

1958 £		£	£
	Endowment Trust Fund:—		
2,564	As at 31st December, 1958	2,564	
	Less Surplus from Income and Expenditure Account	631	
		£1,933	
	Current Liabilities:—		
22,795	X-ray File Fund		26,125
12,707	Publication subscriptions in advance		13,122
3,496	Printing and publishing expenses and amounts in advance		4,743
7,997	Due to Institute of Physics		4,508
£46,995			£48,498

G. P. THOMSON, *President.*
J. TAYLOR, *Honorary Treasurer.*

1958 £		£	£
	Investments:—		
15,657	Quoted	20,657	
10,000	Unquoted	10,000	
	(*Estimated market value at 31st December, 1959 £30,542*)		30,657
2,059	Stock on hand—Publications and dispatch materials ...		2,066
5,356	Sundry debtors		6,707
11,359	Bank balances and cash in hand		7,135
2,564	Endowment Trust Fund		1,933
£46,995			£48,498

We have audited the above Balance Sheet and have obtained all the information and explanations we have required. We have verified the Bank Balances and the Investments. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Fund according to the best of our information and the explanations given to us and as shown by the books of the Fund.

Spencer House, South Place, London, E.C.2.
10th February, 1960

KNOX, CROPPER, GEDGE & CO., *Chartered Accountants.*

THE INSTITUTE OF PHYSICS—BENEVOLENT FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1959

1958 £		£	*1958* £		£
857	To Grants	936	**1,567*	By Subscriptions and donations including tax recovered	1,383
—	„ Expenses	23	*316*	„ Interest and dividends	331
1,375	„ Balance being excess of income over expenditure carried to Capital Account	900	*349*	„ Royalties on books	145
£2,232		£1,859	*£2,232*		£1,859

* Including donation from Phillips Estate of £350.

BALANCE SHEET, 31st DECEMBER, 1959

1958 £		£	£	*1958* £		£	£
	Capital Account:—			*7,042*	Government Securities, at cost ... ... (*Market value at 31st December, 1959, £6,761*)		7,042
	On 31st December, 1958	8,450		*259*	Debtors		214
	Add Transfer for Income and Expenditure Account	900		*622*	Cash at bank—Current Account	1,557	
8,450			9,350	*527*	Deposit Account	537	2,094
£8,450			£9,350	*£8,450*			£9,350

J. TAYLOR, *Chairman of Fund Committee.*
H. R. LANG, *Secretary of the Committee.*

We have audited the above Balance Sheet and have obtained all the information and explanations we have required. We have verified the Bank Balances and the Investments. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Fund according to the best of our information and the explanations given to us and as shown by the books of the Fund.

Spencer House, South Place, London, E.C.2.
10th February, 1960

KNOX, CROPPER, GEDGE & CO., *Chartered Accountants.*

The Institute's Journals

PRINCIPAL CONTENTS OF THE APRIL, 1960, ISSUES

Journal of Scientific Instruments : Volume 37, No. 4

Accurate direct-reading hydrostatic balance. By A. T. J. Hayward.

An apparatus has been built to enable the specific gravity of the water in the sump of the N.E.L. Hydraulic Machinery building to be read directly, with an accuracy of 1 in 50,000. A watertight, hollow, stainless-steel sphere, 15 in. in diameter, loaded with shot so that it just sinks in water, hangs from a semi-automatic balance in a Perspex tank through which sump water is circulated. Tables, based on a previous calibration of the apparatus with distilled water, enable balance readings to be converted directly to specific gravity values for any given temperature from 13·0 to 21·0°C. A cheap form of the apparatus for use in hydraulics laboratories is suggested. The possibility is discussed of increasing the accuracy to better than 1 part per million for research on the density of liquids.

Apparatus for the measurement of Young's Modulus, between −200 and 700°C by transverse vibration in vacuum. By H. J. Stokes, A.Inst.P.

The construction and use of apparatus for the determination of Young's Modulus by means of transverse vibrations of specimens in strip form four inches long are described. Two vacuum chambers are employed, one for immersion in liquid nitrogen and the other incorporating a small furnace for operation at temperatures up to 700°C, the electronic units being common to both. Typical results are included to illustrate use of the equipment, the accuracy of which is claimed to be within ±1% for absolute values.

Automatic decantation for routine sub-sieve sizing. By F. Horsfall and A. Jowett.

Electronic equipment used to control sizing analysis by the beaker-decantation method is described. Capacitor-resistor circuits are used to give appropriate sedimentation times and also to control draining and filling of the decantation apparatus. Except for adjusting a control to alter the sedimentation time when necessary, the operator is free to attend to other duties.

Wax-atomizer for producing spherical dust particles. By G. K. Greenough.

An airblast atomizer is described which produces spherical wax particles suitable for use in the investigation of the aerodynamic behaviour of dust particles.

Position transducer using a divided circle and coded scale. By I. R. Young, Grad.Inst.P.

A small transducer is described in which a coded scale is used to distinguish the lines on a divided circle. This unit is intended as a positional reference in a large data-collecting system. The circle and code are both detected photoelectrically, though using very different cells and lamps. In order to keep the instrument diameter small, the coded scale is made in drum form.

Radiometer for field use. By J. H. McGuire, A.Inst.P., and H. Wraight.

A shielded, gold-disk radiometer, specially designed for field use, is described. It measures thermal radiation in the range 0·01 to 1·2 cal cm^{-2}s^{-1}. The calibration is not greatly affected by ambient temperature or by prolonged exposure and the error introduced by winds of up to 25 mile/h is less than 8%.

New method of sample interchange in a solid-source mass spectrometer. By B. R. F. Kendall.

An ion source is described in which any one of a number of samples on a single filament can be analysed at will. The operation of the source is based on the effects of potential variations along the length of the filament. Results obtained with this and other experimental sources are discussed.

Low-angle Geiger diffractometer for use with monochromatic radiation. By P. W. Teare.

An X-ray diffractometer has been designed to study low-angle scattering from precipitation-hardening aluminium alloys. The special problems of design that arise with this type of instrument are discussed, and their practical solution illustrated by the low-angle diffractometer finally built. The performance of the diffractometer is critically reviewed and a table of results quoted to show the reproducibility obtainable. It is thought possible that proportional counting could greatly improve the diffractometer.

Improved eye-piece graticule for measuring X-ray powder diffraction patterns. By W. G. Perdok and G. Boom.

The accuracy of measuring Debye-Scherrer lines can be improved by a slight modification of the cross-wire system in the microscope. The new graticule can be made simply by photographing a large-scale drawing.

Tunable galvanometer amplifier. By R. M. Huey and B. J. Lancaster.

The construction and performance of a tunable galvanometer amplifier using a photomultiplier tube are described. A tuning range of a little over two octaves with resonant voltage gains of over 10^4 times and Q-values ranging from 1·7 to 7·5 were obtained.

Measurement of cyclic strain. By T. M. Dowell and J. A. Mackinnon.

The paper describes a versatile multi-way instrument for measuring periodic strain gauge signals. The strain is either shown on a meter or can be accurately measured on an oscilloscope in terms of resistance change. Full scale deflexion of the meter is obtained for strains in the order of $\pm 10^{-4}$.

The determination of the profiles of water waves. By J. A. Sandover and C. Taylor.

The capacitor type depth gauge, described in this paper, facilitates accurate recordings of the profiles of three dimensional water waves propagated in prismoidal open channels. The circuitry, principle and calibration of the gauge are outlined, with particular reference to the advantages of using standard industrial equipment.

Instrument for recording the resistance during the deposition of a thin film. By J. A. Bennett, Grad.Inst.P., and T. P. Flanagan, A.Inst.P.

The instrument described enables a decrease in the electrical resistance of a metallic film to be followed during the deposition of the film. This is achieved by recording the instant at which certain fixed resistance values are attained. When one balance point is reached the value of the reference resistance in one arm of a Wheatstone bridge is changed to the next balance point by a uniselector actuated by a valve amplifier.

Improved smoke density recorder. By R. Lambie.

A smoke-density recorder is described in which high stability is achieved by the use of stabilized circuits for the light source and head amplifier. A method of calibration by means of optical-density screens standardized for the type of photocell used is given. Drift caused by deposition of smoke on the optical system was overcome by the use of hot air jets. During extended tests on laboratory and industrial installations, stable operation with negligible drift was obtained.

British Journal of Applied Physics: Volume 11, No. 4

CONFERENCE REPORT

Summarized proceedings of a conference on solid state physics—Melbourne, August 1959. By J. F. Nicholas.

The Australian Branch of The Institute of Physics held a conference on solid state physics in Melbourne from August 17-21, 1959. This conference was the first of its kind to be held in Australia and attracted an attendance of about one hundred and thirty. In all, 46 papers, ranging over a wide field, were presented and these are summarized; they include papers on superconductivity, transport properties, surface properties, optics, theoretical physics, magnetism, plastic deformation and crystal imperfections.

SPECIAL ARTICLE

Very high energy ultrasonics. By E. A. Neppiras.

The field of high power ultrasonics covers the power region where irreversible changes can be produced in the medium. In Table 1 are listed the more important effects and uses of high energy ultrasonics. The field is very large; useful applications now touch almost every industry. In the final column of the table approximate figures are quoted for the order of the ultrasonic intensity required in the various applications. In gases and liquids the intensities obtainable are severely limited. In liquids this limit is fixed by cavitation which sets in at a rather low level. Cavitation can be avoided by pressurization, and then very high energies can be transmitted. But this is inconvenient and seldom used in practice. The field of very high energy ultrasonics is therefore practically confined to solids, as indicated in the table.

The spectral emission of radiation by glass. By J. R. Beattie, A.Inst.P., and E. Coen.

The spectral radiation emitted normally from the surface of a thin sheet of glass having a specified temperature distribution throughout its thickness is calculated for the wavelength range 1·0 to 6·0 μ. From the results obtained, the design of a radiation pyrometer capable of measuring both the surface and inside temperatures of the glass is described. The pyrometer consists of two radiation detectors, one with a filter to measure only the radiation arising from, and hence the temperature of, the surface of the glass, the other with a filter to measure the radiation arising from the interior of the glass and which therefore has a response dependent on the temperature distribution within the glass.

Reflexion electron microscopy using diffracted electrons. By J. S. Halliday, A.Inst.P., and R. C. Newman.

Crystalline surfaces have been examined in the reflexion electron microscope with the angles of illumination and viewing adjusted so that diffracted electrons contributed to the images. In this way, the size and distribution of the diffracting regions have been determined. A resolution of 80 Å has been obtained, which is at least four times better than that obtained in normal reflexion micrographs.

X-ray microbeam study of deformation bands in aluminium. By D. Lewis, A.Inst.P.

An experiment has been devised to measure the relative contribution of plastic bending and mosaic structure to asterism formation. Adjacent X-ray microbeam photographs were taken across a broad deformation band in a crystal of aluminium and the total curvature (estimated from the asterisms) compared with that from a normal X-ray beam covering the same distance. It was shown that the asterism must be mostly due to fragmentation. Orientation determinations show that the raised portion of the band consists mainly of portions of the crystal that have not rotated in accordance with the theory of Taylor and Elam.

Simple rotary dynamic testing machine. By A. N. Gent, A.Inst.P.

A test machine is described for determining the dynamic shear properties of rubber-like materials. It imposes a simple shear deformation, the direction of which is continuously rotated. The observations are easily made, and enable the dynamic shear modulus and damping factor to be determined rapidly; moreover, a relatively wide frequency range seems feasible. The instrument therefore appears suitable for general application. Measurements on a soft butyl rubber vulcanizate are described and compared with observations of free torsional oscillations. Good agreement is obtained.

The test-piece is subjected to a rotating shear of constant amplitude, and hence the elastically-stored energy is held constant. The observed energy dissipation therefore confirms a hypothesis of Greenwood and Tabor, that dissipation may occur under such conditions, and indicates the limitations of the " hysteresis " concept that the dissipated energy is a constant fraction of the elastically-stored energy.

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

Research Laboratories, Leatherhead, Surrey

METALLURGY SECTION

Ref. PB/116

Applications are invited for the following appointments :—

A. **GROUP LEADER**

To take charge of a group investigating problems in ferrous metallurgy arising in the Board's power stations. Much of the work will be concerned with ferritic and austenitic steels for use at high temperatures and candidates should have several years' experience in this field. They should also have a good honours degree or its equivalent in Metallurgy.

B. **GROUP LEADER**

To build up a group to study the more fundamental aspects of problems in ferrous and non-ferrous metallurgy arising in the Board's power stations. Problems of immediate interest include the deformation and precipitation processes occurring in ferritic and austenitic steels during fabrication and in service. An electron microscope, an X-ray diffractometer, and X-ray spectrometer and other specialized services are available to support this work. Candidates must have a good honours degree in Metallurgy or Physics and a sound knowledge of metal physics.

C. **METALLURGISTS AND METAL PHYSICISTS**

To take part in the research described under (B) above. Candidates should have a good honours degree or should be expecting to gain one this summer.

Salaries according to duties and responsibilities, will be on scales within the following ranges : Post A and B, £1,530 – £1,985 p.a. or £1,195 – £1,775 p.a. Post C, £1,195 – £1,775 p.a. or, up to £1,300 p.a.

Applications concerning these appointments, which afford every prospect of advancement, should be made to the Personnel Officer, 24/30 Holborn, London, E.C.1, stating age, qualifications, experience, present position and salary, as soon as possible. Envelopes should be marked " Confidential " together with the reference of the post in which you are interested.

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

requires EXPERIMENTAL PHYSICISTS

(Ref. 1628/110)

To assist in the

1. Final stages of development and subsequent commissioning and operation of the injection system for Nimrod, the 7 GeV Proton Synchrotron now under construction at Harwell for the National Institute for Research in Nuclear Science.

2. Study of some fundamental aspects of accelerator technology and particle beam physics.

Applicants should have G.C.E. at " A " level ; H.N.C. in Applied Physics or equivalent. A degree would be an advantage and a general knowledge of electronics is desirable.

Salary : £510 (at age 20) – £905 p.a. or within £1,045 – £1,285 p.a. and £1,435 – £1,710 according to experience in one or more of the following :—

- (i) Production and handling of high R.F. power at frequencies near 100 Mc/S.
- (ii) Production and insulation of high voltages including high vacuum devices.
- (iii) Production, focusing and measurement of ion or electron beams.
- (vi) High vacuum technology.

Physics Section, Technological Irradiation Group, Isotope Research Division, Wantage Radiation Laboratory

RESEARCH PHYSICIST (Ref. 1597/110), required in a section engaged in research and development associated with gamma irradiation including measurements of energy absorption and shielding. The work also involves basic geometry of irradiation plant using Cobalt 60 and Caesium 137 as large sources, involving problems in handling and shielding.

Qualifications : 1st or good 2nd Class Honours degree and appropriate research experience.

Salary : £1,535 – £2,180 p.a. Housing and Superannuation schemes.

Send Postcard for application forms quoting appropriate reference number to :—

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For details write immediately, quoting S/80 to either

The Director, Bolton Training College, Manchester Road, Bolton.

The Director, Huddersfield Training College, Holly Bank Road, Huddersfield.

The Principal, Garnett College, 83 New Kent Road, London, S.W.1.

(No Science Course at London)

UNIVERSITY OF ADELAIDE
ELDER CHAIR OF PHYSICS

Applications are invited for the abovementioned Chair, which has become vacant through the appointment of Professor L. G. H. Huxley as Deputy Chief Executive Officer of C.S.I.R.O. Potential candidates are invited to obtain from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or from the Registrar, a general statement about the present research and teaching activities of the Department and formal terms of appointment. Those in the United Kingdom may also borrow from the Secretary, A.U.B.C., a coloured film illustrating the University and the city of Adelaide. Particulars of schemes for financial help in the purchase of a house may be obtained from the Regstrar; the University will gladly supply further information on request. The salary at present attached to the Chair is £A3,500, with superannuation on the F.S.S.U. basis; it is expected that this salary will be increased in 1961. Applications (in duplicate) giving the information listed in the statement, should reach the Registrar, The University of Adelaide, Adelaide, South Australia, not later than May 31, 1960.

UNIVERSITY OF ST. ANDREWS

Applications are invited for an EDWARD A. DEEDS FELLOWSHIP in Queen's College, Dundee, for research in engineering, metallurgy, chemistry, physics, mathematics or any cognate subject, from October 1, 1960. The Fellowship (open to persons of either sex) will be tenable for three years. The amount will be £900 per annum, subject however to upward revision ; F.S.S.U.; Family Allowance ; University Lecturer status. Fellow may be required to do a limited amount of teaching in the Department in which appointed. Applications (ten copies) with names of three referees, to the undernoted, not later than May 10, 1960. Patrick Cumming, Joint Clerk to the University Court, Queen's College, Dundee.

NATIONAL GAS TURBINE ESTABLISHMENT, Ministry of Aviation, Pyestock, Farnborough, Hants, requires ELECTRONIC ENGINEERS for (1) design and development of instrumentation associated with gas turbines and allied research ; or (2) operation, maintenance and servicing of a digital computer and associated instrumentation. Qualifications: G.C.E. (Advanced Level), pass degree, H.N.C. (physics or electrical engineering) or equivalent. Previous experience of modern electronic apparatus and instrumentation techniques desirable. Appointments as (*a*) Experimental Officer (minimum age 27) or (*b*) Assistant Experimental Officer. Salary ranges : (*a*) £954 – £1,166, (*b*) £382 (age 18) – £670, (age 26) – £830 (male). Women's rates same by 1961. Opportunities to compete for established (pensionable) posts. Forms from Ministry of Labour, Technical and Scientific Register (K), 26/28 King Street, London, S.W.1, quoting D143/0A.

COMMONWEALTH OF AUSTRALIA

WEAPONS RESEARCH ESTABLISHMENT

OPTICAL DESIGN and INSTRUMENTATION

The Department of Supply invite applications for the following vacancies at the Weapons Research Establishment, Salisbury, near Adelaide :—

POSITION : Experimental Officer, Grade 3. (Two (2) positions.)

SALARY : £A1,730/1,950.

DUTIES : (Pos. No. 242)—Evaluation of lens systems of optical instruments, including the investigating of new techniques such as frequency response (contrast transfer) techniques for lens testing.

QUALIFICATIONS : Degree or equivalent in Physics or Mathematics and some experience in making precise physical measurements.

DUTIES : (Pos. No. 171)—Development of optical/mechanical devices for flight measurements on guided missiles and high altitude rockets.

QUALIFICATIONS : Degree or equivalent in Engineering or Physics and some relevant experience.

NOTE : Assistance will be given in obtaining housing accommodation.

CONDITIONS : The successful applicants, if they desire, may choose to enter into an agreement for a three (3) year contract of employment in Australia. In this case, the Commonwealth will bear the cost of return fares, together with the cost of removing each way the successful applicant's furniture and effects up to a maximum cost of £500 (Aust.), £250 each way. Under specified conditions, first class air/sea transport for the appointees and dependants (wife and dependent children) will be provided by the Commonwealth.

APPLICATIONS : Forms obtainable from Senior Representative (AV.53/10), Department of Supply, Strand, London, W.C.2, with whom completed applications should be lodged by April 29, 1960.

BRITISH NYLON SPINNERS LIMITED

have a vacancy for an

X-RAY CRYSTALLOGRAPHER

The work includes the application of low angle X-ray scattering and microbeam techniques to structural and tectural problems of high polymers in both massive and filamentous forms. Knowledge of the techniques is highly desirable and applications from physicists or chemists who have had suitable academic or industrial research experience would be particularly welcome. The general conditions of employment are in line with the best available in this country, the Research Department is situated in particularly delightful countryside and housing need not present difficulty to a married man.

Applications should be addressed, quoting Ref. R/46, to the :

Personnel Manager,
British Nylon Spinners Limited
Pontypool

ASSISTANT PHYSICIST

required for X-ray diffraction work with a metallurgical bias. Previous experience not essential but applicants should be of H.N.C. or Pass Degree level or be a Grad.Inst.P.

Please write to the

Personnel Officer
Fairey Aviation Limited
Hayes, Middlesex

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Name.......................... Date of Birth..........................
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Address ....

These policies are of particular interest to physicists.

For further details please complete this form and send to:

WALTER HERRIOT & CO. LTD.
Incorporated Insurance Brokers
Broad Street House, 54 Old Broad Street, London, E.C.2
(Telephone: LONdon Wall 7007/8)

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
ST. JOHN STREET, LONDON, E.C.1
DEPARTMENT OF PRODUCTION TECHNOLOGY AND CONTROL ENGINEERING

I. Applications are invited from Honours graduates for the post of READER in this newly formed Department. The work of the Department is primarily concerned with the Diploma in Technology and postgraduate courses. The person appointed will pursue one of the three main interests of (i) measurement and automatic control, (ii) production methods and processes, (iii) industrial organization, and will be required to devote most of his time to the development of research in his chosen field and the supervision of research students. Salary scale: £1,800 × £50 – £2,100 per annum, plus London allowance of £38 increasing to £51 at age 37. A modicum of private consulting practice by the appointed person will be encouraged. Particulars and forms of application from the Secretary.

II. Applications are invited from Honours graduates for the post of PRINCIPAL LECTURER in production methods and processes. The work of the Department is primarily concerned with the Diploma in Technology and postgraduate courses. The person appointed will be responsible for leading the work in his subject at undergraduate and postgraduate Honours level and for developing research and the laboratories of the Department. Salary Scale: £1,788 × £50 – £1,951 per annum. A modicum of private consulting practice by the appointed person will be encouraged. Particulars and forms of application from the Secretary.

III. Applications are invited from graduates for posts in the class of LECTURERS in this newly formed Department. The vacancies arise from the expansion of the work which is primarily concerned with the Diploma in Technology and postgraduate courses. The persons appointed will pursue one of the three main interests of the Department, namely: (i) measurement and automatic control, (ii) production methods and processes, (iii) industrial organization. They will be encouraged to undertake research or development work and may be required to assist in industrial liaison. Salary scales range from £895 to £1,750 per annum with a London allowance at each point of £38 (£51 at age 37 upwards). A modicum of private consulting practice is encouraged. Particulars and forms of application from the Secretary.

OPERATONAL RESEARCH, AIR MINISTRY. SENIOR SCIENTIFIC and SCIENTIFIC OFFICERS required in Scientific Adviser's Department. Qualifications 1st or 2nd class honours degree in mathematics, statistics or physical science such as physics, engineering. Honours degree in natural or social science if candidate possesses at least mathematical knowledge at G.C.E. advanced level. Applications will also be considered from undergraduates who will be completing their degree course this year. Appointments offer great scope and interest to versatile scientists capable of working well with Service officers and of adopting methods suited to Service environment. Work is mainly operational research in variety of subjects of concern to R.A.F. including tactics, technical development and logistics and offers Senior Scientific Officer and Scientific Officer entrants valuable experience in principles of operational research. Salaries: London Senior Scientific Officer £1,233 to £1,460; Scientific Officer £655 to £1,150. Outside London slightly lower. Salaries for women being raised by stages to men's rates. Forms from Ministry of Labour Technical and Scientific Register (K), 26 King Street, London, S.W.1 (quoting A 104/OA). Closing date April 25, 1960.

UNIVERSITY OF READING

Applications are invited for a LECTURESHIP IN PHYSICS. The successful candidate will be expected to take up his duties on September 30, 1960, if possible. Further particulars may be obtained from the Registrar (Room 22, O.R.B.), The University, Reading, by whom applications should be received by May 23, 1960. Late applications from abroad may be considered. Four copies of an application, with the names of two referees, will be required.

R.R.E. RESEARCH FELLOWSHIPS

MINISTRY OF AVIATION invites applications for Senior and Junior Research Fellowships tenable for three years at the Royal Radar Establishment, Malvern, commencing Autumn, 1960. Considerable choice of subjects within the fields of interest to the Establishment. These include experimental and theoretical research in low temperature physics ; electrical and optical properties of semi-conductors ; infra-red spectroscopy ; microwave physics including resonance techniques ; electronics and radio astronomy. Candidates must be British with normally a first or second class honours degree in an appropriate subject, with evidence of a very high standard of ability in research. Exceptionally a candidate without the requisite academic qualifications, but who can produce evidence of outstanding ability in research, may be admitted. At least two years' postgraduate research experience required for Junior Research Fellowship (age preferably 23-26) and three years for Senior Rsearch Fellowship (age preferably 26-30). Remuneration according to individual merit on ranges £1,150 – £1,400 (Senior Research Fellowship), £800 – £1,100 (Junior Research Fellowship) a year. Superannuation under F.S.S.U. At expiry of Fellowship the holder, if of suitable age, can be considered for an established post. Application forms from the Director, R.R.E., Malvern, Worcestershire, for return by April 22, 1960.

TECHNICIANS

RESEARCH INSTITUTE, PIRBRIGHT, invites applications for ASSISTANT in experimental instrument workshop. Applicants should have several years' experience in fine machine shop practice and an interest in the associated electrical/electronic aspects of apparatus construction. Basic wages £9 9s. 8d. with merit pay up to £3 10s. depending on age, experience and qualifications. Applications to Secretary by April 20.

COURSES

BATTERSEA COLLEGE OF TECHNOLOGY
(A College of Advanced Technology)
LONDON, S.W.11

Postgraduate courses in crystallography consisting of one year full-time or two years part-time, will begin on October 3, 1960. These courses prepare for either the Internal degree of M.Sc. (Crystallography) of the University of London, or the College Postgraduate Diploma (D.C.T. (Batt.)). Scholarships are available in certain circumstances. For further details apply to the Senior Lecturer-in-charge of the Crystallography Section.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
LONDON, S.W.7

A course of six postgraduate lectures on " Flame Processes in Flowing Gases " will be given in the Department of Chemical Engineering by Dr. F. J. Weinberg on Mondays at 2.30 p.m., commencing May 2, 1960. Further particulars from the Registrar.

COUNTY BOROUGH OF ROTHERHAM
EDUCATION COMMITTEE
ROTHERHAM COLLEGE OF TECHNOLOGY
DEPARTMENT OF PHYSICS

A short full-time course in high vacuum technology will be held during the period Monday, June 27, to Friday, July 1, 1960, from 9.30 a.m. to 5.00 p.m. daily. Topics will include vacuum deposition, degassing and leak detection. Further particulars may be obtained from the Registrar, College of Technology, Howard Street, Rotherham.

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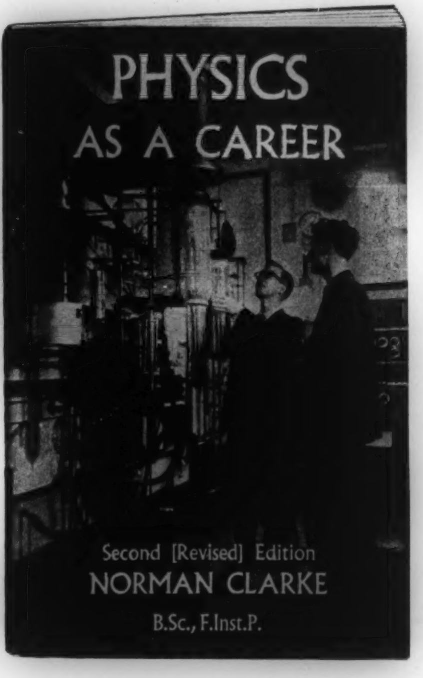

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Machinery Lloyd.

"Well-written and authoritative little book .... a most useful survey of physics as a career .... every grammar and public school with a science side will need it."

The School Librarian.

" .... a clear, concise and well written account of the fields of work open to those who intend to enter the profession of physics and the remuneration to be expected."

Journal of the
Royal Institute of Chemistry.

" invaluable." *Education.*

" contains a great deal of practical information and advice .... other professional bodies would do well to commission surveys of a similar kind." *Glasgow Herald.*

" well written and well illustrated. .... There should be a copy in every school library in Britain." *Boy's Own Paper.*